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OLIVER EVANS AND HIS INVENTIONS.*

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Of all the early American Mechanics, there is perhaps none who has left a more definite impress upon the industrial progress of our country than Oliver Evans, and there is none whose successes and failures are of more interest to the student of mechanical history. He is widely recognized as the inventor of improvements which completely revolutionized the processes of flour manufacture, and which remain in use to-day substantially as he left them.

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But it is not alone as an inventor of flour making machinery that he claims our attention, he is even more widely known for his earnest and successful efforts to introduce the high pressure steam engine, and by his enthusiastic advocacy of steam locomotion. Indeed, he has been styled the "Father of the High-Pressure Steam Engine," and it has been often said that he was the original projector of the locomotive and the inventor of the first practicable steamboat. These broad claims have generally been maintained by American writers and ignored by the English, who give much the same credit to Richard Trevethick, Oliver Evans's contemporary. It is, of course, difficult in any such case to clearly establish general claims to priority in the conception of ideas, but we can at least compare his work with that of other inventors of his time and form some judgment as to their relative merits. With this in view, it will be our task this evening to review briefly the life and labors of Oliver Evans, to acquire, if we can, a just appreciation of the true value of his work and his proper place among those geniuses to whom we owe the mechanical attainments of the present age; to learn, if we may, who and what he was, and what his environment; to learn the meagreness of his opportunities, the restrictions by which he was hampered, that we may the better understand the character and value of his inventions, and the measure of credit to which he was entitled.

Unfortunately, what is recorded of his life can be told in a few words, and is, indeed, little more than a history of his work. He was born near Newport, Del., in 1755, and died in New York City in 1819.

When he was born our country showed scarcely a trace of its present industrial development. The Atlantic seaboard was sparsely settled throughout its length, and a few adventurous pioneers were forming occasional settlements beyond the Alleghanies. Not only were there no railroads and no canals, but there were no tolerable highways of any kind except in the neighborhood of the larger towns. The goods required by the settler on the Ohio or Lake Erie were packed on horseback over the mountains, through Pennsylvania, by Lancaster and Chambersburg, or by the Southern route through Virginia, by Winchester, Hagerstown and Cumberland. It was not until 1789 that the first wagon load was sent over the Southern route to the

shores of the Ohio. These four-horse wagons would haul twenty hundred-weight from Hagerstown to Pittsburgh and back in about a month, and charge $3 a hundred-weight for hauling. Salt packed over the mountains sold in Pittsburgh for $8 a bushel as late as 1796, when salt from Western New York was introduced at half that cost.*

When Oliver Evans was born, there was just one steam engine on the American Continent; before he died, steam engines were in common use. During his life, good turnpikes were completed, canals projected and partly built, and steamboat navigation established on the great rivers. These were vast strides; but the crowning achievement, the railroad, which his prophetic eye discerned so clearly, he did not live to see an accomplished fact.

Evans was apprenticed at the age of fourteen to a wheelwright. He was a thoughtful, studious boy, who devoured eagerly the few books to which he had access, even by the light of a fire of shavings, when denied a candle by his parsimonious master. He says that in 1772, when only seventeen years old, he began to contrive some method of propelling land carriages by other means than animal power; and that he thought of a variety of devices, such as using the force of the wind and treadles worked by men; but as they were evidently inadequate, was about to give up the problem as unsolvable for want of a suitable source of power, when he heard that some neighboring blacksmith's boys had stopped up the touch-hole of a gun barrel, put in some water, rammed down a tight wad, and putting the breech into the smith's fire, the gun had discharged itself with a report like that of gun-powder. This immediately suggested to his fertile mind a new source of power, and he labored long to apply it, but without success, until there fell into his hands a book describing the old atmospheric steam engine of Newcomen, and he was at once struck with the fact that steam was only used to produce a vacuum, while to him it seemed clear that the elastic power of the steam if applied directly to moving the piston, would be far more efficient. He soon satisfied himself that he could make steam wagons, but could convince no one else of this possibility. At the age of twenty-two, he had completed a successful machine for making the wire teeth of wool cards, and

* Bishop's *History of American Manufactures.*

then invented, but did not build, a machine for making and sticking the teeth in the leather backs. In 1780, he married the daughter of John Tomlinson, a Delaware farmer, and removed to Queen Anne County, Md., where he opened a store. Here he seems to have remained until 1782, when his two brothers, who were practical millers, persuaded him to join them in building a merchant flour mill in Newcastle County, Del. They started the mill September 5, 1785, and it required the constant attention of three men with "half the time of a boy." Evans was disgusted with the crude and laborious methods then in use and worked out a system of mechanical devices which could replace the labor of the attendants. In the old mill, the wheat or meal was handled at each stage of manufacture, and was carried from one point or one machine to another by manual labor. This he entirely revolutionized, and when he had applied his improvements, he found that the mill which formerly required more attention than three men could give was easily managed by one man; indeed, Evans wrote that once when a committee of millers came to see his new machinery, he took care to be at work in a neighboring hay field; they found the mill open and at work; and walking over it they saw that all the operations of milling were going on without the care of any attendant—cleaning, grinding and bolting all in progress without human intervention. This, Evans thought, would be convincing, but, they returned home and reported the whole contrivance "a set of rattle-traps unworthy the attention of men of common sense."

Having worked out his improved system and demonstrated its practical value, he set about putting it into general use. This he proposed to do by selling "rights" to millers; and he and his brothers canvassed Maryland, Pennsylvania, Delaware and Virginia without success, although they offered the right free to the first miller in any county who would put in the improvements. The greatest obstacle to his success was the obstinacy of the millers of the Brandywine, whose mills were the most celebrated in the country. They declined to put in his machinery on any reasonable terms, although he had shown them what it appears should have been a convincing proof of the value and utility of his improvements.

Oliver Evans was one of those discontented men who are not satisfied to do things in the time-honored, but perhaps clumsy way

in which they have always been done, and constantly sought opportunities to improve existing methods, and I fancy he generally found them. Certainly, the flour mill of the period badly needed mechanical assistance. Thomas Ellicott, who helped Evans in the preparation of his *Millwright and Millers' Guide*, in 1795, wrote that when he first began the business (about 1757): "Mills were at a low ebb in this country; neither burr-stones, nor rolling screens being used; and but few of the best merchant mills had a fan. Many carried the meal on their backs, and bolted it by hand even for merchant work; * * * it was counted extraordinary when they got their bolting to go by water; after fans by hand, and standing screens; then burr-stones, rolling screens, and superfine bolting cloths with a number of other improvements, some of the latest are the elevators, hopper-boys, etc., invented by Oliver Evans, late of Delaware, tho' now of Philadelphia. * * * By them the manufacture of grain into flour is carried on by water, with very little hand labor and much less waste, either in small or large business. And I do believe, that taking a large quantity of wheat together, that we can make two or three pounds more out of a bushel by the new than by the old way, although it be equally well ground; because it is so much more completely bolted, and with less waste. In the old way, the wheat is weighed and carried up one or two pair of stairs, and thrown into garners; the bags often having holes in, it is spilt and trampled under foot; several pounds being frequently lost in receiving a small quantity, and when it is taken from these garners, and carried to the rolling screens, some is again wasted, and as it is ground it is shovelled into tubs, a dust is raised, and some spilt and trampled on; it is then hoisted and spread, and tossed about with shovels, over a large floor, raked and turned to cool, and shovelled up again and put into the bolting hopper; all which occasions great labor, besides being spilt and trampled over the mill, which occasions a considerable waste. Besides these disadvantages, there are others in attending the bolting hoppers; being often let run empty, then filled too hard, so that they choke, which occasions the flour to be very unevenly bolted; sometimes too poor, and at other times too rich, which is a considerable loss; and when the flour is bolted, it is much finer at the head than the tail of the cloths; the fine goes through first, and has to be mixed by hand, with shovels or rakes;

and this labor is often neglected or only half done; by this means, part of the flour will be condemned for being too poor, and the rest be above the standard quality. The hoisting of the tail flour, mixing it with bran by hand and bolting it over, is attended with so much labor that it is seldom done to perfection."

It thus appears that the improvements in milling, which were originated by Evans, were chiefly in devices for handling the grain and its products during the processes of manufacture without the employment of manual labor. These devices were of various kinds, adapted to the nature of the service they were to perform, and in his publications Evans claimed five different ones, viz.: the *elevator*, for raising vertically; the *descender*, transferring down an incline; the *conveyor* and the *drill*, for moving horizontally, and the *hopper-boy*, whose function was to spread and cool the meal and feed it regularly into the bolting hopper. The *elevator*, perhaps the most important of these, was a modification of one of the oldest of machines, the "chain of pots," which had been used for raising water from time immemorial. As modified for raising grain, it was constructed of an endless flat band or strap, carried upon two drums or pulleys, and upon which, at regular intervals, a number of small troughs or buckets were so arranged that in passing under the lower pulley the buckets filled, and in passing over the upper one emptied themselves into a suitable box, from which a spout discharged the contents as required, the apparatus being kept in motion by power applied to the upper pulley. This machine has been vastly increased in size and capacity since Oliver Evans first put it to work in his little New Castle mill, and it is now applied to a multitude of uses that were never contemplated by him; but the device is essentially the same, and has proved itself to be one of the most useful of his inventions. The *descender* he himself described as "a broad, endless strap, of very thin, pliant leather, canvas, or flannel, etc., revolving over two pulleys, which turn on small pivots, in a case or trough, to prevent waste, one end of which is to be lower than the other. The grain or meal falls from the elevator on the upper strap, and by its gravity and fall sets the machine in motion and discharges the load over the lower pulley. There are two small buckets to bring up what may spill or fall off the strap and lodge in the bottom of the case." Although this machine would work by gravity even when the

descent was small, yet Evans recommended that power should be applied to it where practicable; and when driven in this way it became the prototype of the *belt conveyors* of the present day, which are generally used for the horizontal movement of grain in large quantities. Concave carrying rollers, or other devices, are now employed to compel the belt to form a trough which will hold a greater amount of grain than would stay on a flat belt. Evans also used for the same purpose the *drill*, which was simply an elevator laid horizontally, with wooden cleats, or, as he called them, "rakes," instead of buckets. These rakes scraped the grain along the bottom of the case or box in which they ran. The *conveyor* was simply a quick pitch screw of two or more threads, running in a trough or box into which it fitted closely. This screw, when used for grain, Evans made of a round wooden shaft, around which he nailed two or more sheet iron helices, or spirals, which, when the shaft was rotated, forced the grain along in the trough. When he desired to move flour or meal, he substituted for the sheet metal helix a number of radial arms, arranged spirally around an octagonal shaft.

The *hopper-boy* consisted of a slowly rotating vertical shaft, or spindle, the lower end of which passed through a horizontal beam, upon whose lower surface were arranged a number of inclined boards called "flights," whose function was to spread the meal and to gather it towards the bolting hopper. The horizontal arm also carried a "sweeper," or scraper, which pushed the meal into the hoppers, which were situated in the floor near the base of the vertical post. The meal was allowed to fall from the elevator at the extremity of the arm, which carried on each end an adjustable scraper, whose function was to drive the meal before it, trailing it in a circle, so as to discharge its load by the time it again reached the elevator. This circle of meal was collected by the "flights" and forced into the hoppers as described. The first flight, or that next to the scraper, could be swivelled so as to pile the meal in a ring to allow it more time to cool. As this ring increased in thickness, the arm rose on the spindle to suit. This was rendered easier by the fact that it was counterweighted over a pulley near the top of the spindle. The arm fitted loosely to the spindle, and was provided with an upper bearing of iron, by means of which it could be levelled, and it was driven by

means of a rope from a cross-beam near the top of the spindle. In order to deflect the grain delivered from an elevator in any particular bin, Evans used a pivoted wooden spout which could be rotated to suit his needs. All of these devices were efficient means of accomplishing the end in view, and were all of such a simple character that they could be readily constructed by the millwright with ordinary tools and materials.

At this time, the U. S. Patent Office had not been organized, and the several States exercised the privilege of granting exclusive rights to the use of inventions within their own boundaries. In 1786, Evans applied to the Legislature of Pennsylvania for a right to use his improvements in machinery for making flour, and also to use his steam wagons on the roads of the State. During this year, he explained his proposed engine to several people, and in particular his plan for propelling boats by paddle-wheels turned by steam engines. The following year, the legislature granted his flour mill patent, but made no allusion to the steam wagon claim; but on May 21st, the Legislature of Maryland granted both rights for fourteen years, on the ground that although it would doubtless do no good, yet it certainly could do no harm. A similar patent was subsequently granted (1789) by New Hampshire. About this time, the Ellicotts, well-known millers on the Patapsco, in Maryland, adopted Evans' improvements with great success, so that in making about 325 barrel of flour daily, they saved annually in wages $4,875, and increased the percentage of flour obtained from the wheat so as to reduce the cost of flour fifty cents per barrel, which amounted, Evans says, to a total saving of $32,500 yearly. In 1790, when the U. S. Patent Office was organized, Evans relinquished his State rights, and December 18, 1790, a U. S. patent was granted for his "method of manufacturing flour and meal." This is said to be one of the three patents granted that year. In 1794, he arranged with a Mr. Joseph Stacey Sampson, of Boston, to introduce and patent his steam engine improvements in England, and he furnished him with full drawings and specifications for this purpose. It is said that Mr. Sampson showed these papers to many English engineers, but that he died in England without having done anything to further Evans's interests.

Some time previous to 1790, Evans had removed to Philadelphia, and soon began the preparation of the *Millwright and Miller's*

Guide, which appeared in 1795. This book took three years to prepare, during which time he exhausted his capital, injured his eyes, and became gray. The first edition was of 2,000 copies, was published by subscription, and sold for $2 each to subscribers. He says that during this time his wife sold tow cloth of her own make to help feed their large family. In 1800, he had a mill about Third and Market Streets, and the next year was selling mill supplies at the southeast corner of Ninth and Market Streets.

Having tried in vain to induce some one to advance him the necessary capital to build an experimental traction engine, he began the work, in 1801, on his own responsibility, being moved thereto, he says, by sense of his obligations to the State of Maryland, which had granted him a patent when all others scouted at his visionary scheme. Before he had completed his engine, he concluded that as it differed from any of those then in use, it might be worth while to make some other application of it. He, therefore, changed his plans and started a small stationary engine, 6-inch cylinder, 18-inch stroke, which he had running in the winter of 1802, on Market Street. He set it to grinding and breaking plaster of Paris, then recently introduced as a fertilizer, and it broke and ground twelve tons in twenty-four hours; or when applied to sawing, with twelve saws, it cut up 100 feet of marble in twelve hours. This little engine and boiler cost him $3,700, including his own time, which he valued at $1,000. It took all his capital, and again, he tells us, he was impoverished. The success of this little engine lead to an order for one to drive a steamboat on the Mississippi. The boat was built 80 x 18 feet, at New Orleans, where Evans sent the engine. A freshet, however, left the boat stranded far from the river's edge, and while awaiting another rise to get her off again, the engine was removed and set to sawing lumber. This it did at the rate of 3,000 feet in twelve hours, which sold for $60 a 1,000, and in this time burned a cord and a-half of fuel. It is worthy of remark that this engine ran for a year without failure of any sort. An incendiary fire, attributed to the hand sawyers, whose business was injured by the engine, destroyed the mill, and the engine lay idle for nearly ten years, when it was again put to work, this time driving a cotton press. The boat and engine involved a loss of $15,000 to the enterprising owners.

In 1803, Evans started in business as a regular engine builder and he was probably the first in the United States to make a specialty of this work. The Philadelphia Board of Health ordered of Evans, in 1804, a steam dredging machine for cleansing the docks of the city. This machine he called the "*Oruktor Amphibolos*" or Amphibious Digger, and he described the craft and its performances as follows: "It consists of a heavy flat-bottomed boat, 30 feet long, and 12 feet broad, with a chain of buckets to bring up the mud, and hooks to clear away sticks, stones and other obstacles. These buckets are wrought by a small steam engine set in the boat, the cylinder of which is 5 inches diameter and the length of stroke 19 inches. This machine was constructed at my shop, one and one-half miles from the river Schuylkill, where she was launched. She sunk nineteen inches, displacing 551 cubic feet of water, which at 62·5 pounds, the weight of a cubic foot, gives the weight of the boat, 34,437 pounds, which divided by 213, the weight of a barrel of flour, gives the weight of 161 barrels of flour that boat and engine are equal to. Add to this the heavy pieces of timber and wheels used in transporting her, and the number of persons generally in her, will make the whole burden equal to at least 200 barrels of flour. Yet this small engine moved so great a burden with a gentle motion up Market Street and around the Centre Square; and we concluded from the experiment that the engine was able to rise any ascent allowed by law on turnpike roads, which is not more than four degrees. Before launching, July, 1805, this machine was run during several days around Centre Square, and the daily papers of that time contain an advertisement by Evans, in which he invited those interested to visit the square and inspect the *Oruktor Amphibolos;* he also mentioned that twenty-five cents a piece would be collected from those of the spectators who felt disposed to contribute it, and said that one-half of the sum thus realized he proposed to retain himself, and promised to expend it in the prosecution of other useful inventions; the remaining half of this money he proposed to divide among his workmen who, he further said, at their own expense, provided the wheels and axles upon which the scow was mounted, those first made having failed on account of their inability to support the great weight put upon them. Finally the scow was launched at Market Street Wharf, the engine having been connected with the paddle

wheel, she steamed down the Schuylkill and up the Delaware to her dock."

Having satisfied himself that he could build a traction engine, he made September 26, 1804, a statement to the managers of the Philadelphia and Lancaster Turnpike Company, in which he set forth the comparative expense of hauling by steam and horse-power, and showed conclusively, in his estimation, that by adopting his proposed engines they could nearly treble the net profits they made with the Conestoga wagons. He proposed that this traction engine should carry 100 barrels of flour, travel three miles per hour on a level road, and one mile an hour up and down hills, and it was to make the trip to Columbia in forty-eight hours; while to carry the same load in the usual way took five wagons, with five horses each, seventy-three hours. No attention seems to have been paid this document, and in December of the same year we find him petitioning Congress to extend the term of his flour mill patents. The bill passed safely to a third reading when an unexpected opposition arose which caused its defeat. While anticipating the favorable action of Congress, Evans advertised a new book to be entitled *The Young Engineer's Guide*, upon which he proposed to expend $3,000 and produce a very exhaustive and valuable work. Completely disheartened by the failure of his bill, and deprived of the additional royalties he felt sure of getting, he was obliged to issue a much smaller book than he had intended, and to omit many of the illustrations which he had promised. This abridged volume, he called *The Abortion of the Young Engineer's Guide.*

Evans expected great things from the extension of his patents, for although his royalties had been very low, yet comparatively few millers adopted his inventions, while the first patents were in force. After their expiration, the millers hastened to avail themselves of the advantages offered by his improvements and when, in 1808, Congress finally passed a bill continuing his patent rights for twenty-two years and protecting him for the interval between the expiration of his first patents and the date of the regrant, Evans felt that better days had at last dawned upon him. He put up prices from $30 for one pair of four and one-half feet stones to $300, and from $200 for five pairs of seven-feet stones to $3,675; but no great success appears to have attended this move, for

whereas some mill-owners, Thos. Jefferson, for instance, paid the license; most of them refused and were only compelled by process of law, which involved the inventor in a series of expensive and troublesome litigations. It is probable, however, that from this time his circumstances were somewhat more comfortable.

In 1803, Mr. B. H. Latrobe, in his report to the American Philosophical Society, describes five or six engines then at work in the United States, and among others mentions "a small engine erected by Mr. Oliver Evans." This was doubtless his first engine, that which he started the year previous to Mr. Latrobe's report.

In 1807, he established the Mars Works, at the corner of Ninth and Vine Streets, Philadelphia, and announced himself as an iron founder and steam engineer. This business he carried on until his death. In 1810, he associated with him his sons-in-law, James I. Rush, and David P. Muhlenberg, and shortly afterwards they purchased the lot at the corner of Sixteenth and Buttonwood Streets, which is now occupied by a portion of Mr. James Moore's Bush Hill Iron Works.

In 1812, he mentions ten of his engines as being then in use, and four years later he claims fifty. In 1817, he received an order for an engine and boilers for the Fairmount Water Works. This engine had a 20-inch cylinder, 5-foot stroke and was started in December of that year. It was supplied by four cast-iron boilers, 30-inch diameter, 24 feet long, carrying steam at pressures ranging from 194 to 220 pounds per square inch. Its product was 3,072,606 ale gallons, pumped 102 feet high in twenty-four hours, at an expenditure of 1,660 cubic feet of wood. It does not appear to have been an entire success, and the boilers burst on three different occasions.

Evans seized every opportunity to press his claims for the high-pressure engine. He set forth his views at some length in *The Abortion of the Young Engineers Guide*, in 1805, describing his engine and its application to various duties, gave rules for pressure and point of "cut-off," and recommended a cylindrical boiler, 3 feet diameter, with a maximum length of from 20 to 30 feet. In this work, he republished some of his previous papers and also the acrimonious correspondence carried on in the *Repository* between himself and Col. Stevens, of Hoboken, N. J., in which he accused the latter of appropriating his ideas. In this

work, Evans also described his projected volcanic steam engine, in which the products of combustion were to be passed into the water to assist in vaporizing it; and he also set forth a scheme of mechanical refrigeration.

In the *Emporium of the Arts and Sciences*, Vol. 2, published in Carlisle, Pa., 1812, we find quite an extended account of the state of the steam engine at that period, and the feeling against the use of high-pressure steam is well illustrated by an account of the explosion of one of Trevethick's boilers with fatal effect. This fear of the power of high-pressure steam dated from the time of Watt, who thought Richard Trevethick ought to have been hanged for using it, and was a potent factor in the opposition which Evans encountered in his efforts to introduce his engine. In the *Emporium*, he gave an account of his "Columbian Condensing High-Pressure Steam Engine," somewhat modified from that shown in his earlier publications; he also described the progress of his invention and reiterated his offer to make a steam carriage that would "run on good level railways," at the rate of fifteen miles an hour; and repeated his oft-quoted prophecy as to the future of the railroad.*

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* "The time will come when people will travel in stages moved by steam engines from one city to another almost as fast as birds fly—fifteen to twenty miles an hour. Passing through the air with such velocity—changing the scenes in such rapid succession—will be the most exhilarating, delightful exercise. A carriage will set out from Washington in the morning, and the passengers will breakfast at Baltimore, dine at Philadelphia, and sup at New York the same day.

"To accomplish this, two sets of railways will be laid so nearly level as not in any place to deviate more than two degrees from a horizontal line, made of wood or iron, on smooth paths of broken stone or gravel, with a rail to guide the carriages so that they may pass each other in different directions and travel by night as well as by day; and the passengers will sleep in these stages as comfortably as they do now in steam stage-boats. A steam engine that will consume from one-quarter to one-half a cord of wood will drive a carriage 180 miles in twelve hours, with twenty or thirty passengers, and will not consume six gallons of water. The carriages will not be overloaded with fuel or water. * * * And it shall come to pass that the memory of those sordid and wicked wretches who oppose such improvements will be execrated by every good man, as they ought to be now.

"Posterity will not be able to discover why the Legislature or Congress did not grant the inventor such protection as might have enabled him to put in operation these great improvements sooner—he having asked neither money nor a monopoly of any existing thing."—*Extract from Address to the People of the United States.*

Evans again appeared in print in 1815, when he published an address to the people of the United States, in which he offered the use of his patented improvements in steam engines for propelling boats or land carriages upon liberal terms to any who would form companies for the purposes of using them. In 1816, he published "An Exposition of Part of the Patent Law by a Native-born Citizen of the United States, to which is added Reflections on the Patent Laws." During his struggle to secure from Congress an extension of his patent rights, Evans issued a pamphlet entitled "Oliver Evans to His Counsel who are Engaged in the Defense of His Patent Rights for the Improvements He has Invented, Containing a Short Account of Two out of Eighty of His Inventions, their Use and Progress in Despite of All Opposition and Difficulty, and Two of his Patents with Explanations."

The "drawings and specifications" of the eighty inventions mentioned in this formidable title were ruthlessly committed to the flames in the presence of his assembled family, while he was suffering under the mortification caused by the defeat of his application to Congress; and there is every reason to believe that he ever afterwards sincerely regretted this foolish act.

In April, 1819, Evans was visiting in New York City, when he received the distressing information that his Philadelphia shop had been destroyed by an incendiary fire. This news appears to have brought on a fatal attack of apoplexy, and he died on the twenty-first of the month. Thus ended in a new and bitter disappointment the life of one whose existence seems to have been one long struggle against the incredulity and prejudice of those whom he sought to benefit. He lacked the capital to carry out his cherished schemes and keenly felt the apathy which prevented the accomplishment of his great purposes.

His life, though full of disappointments, was not without its compensations; the success of his steam engine was itself a triumph and a vindication, and the universal adoption of his mill improvements afforded him more or less remuneration, and increased his business as a millwright and engineer. In regard to these improvements, there can scarcely be two opinions, his own testimony is amply supported by contemporary evidence that is unassailable. His theories of physics, especially of thermo-dynamics were doubtless, many of them faulty enough as might be expected from one whose

scientific knowledge was so scanty, and whose books were so few; but his mechanical ideas were seldom at fault, and his constructions were the best that his opportunities afforded. His application of the ancient chain of pots to lifting solids was a most felicitous conception, and has found its way into many other branches of industry not contemplated by him.

His system of handling grain, modified in detail only, in principle the same as he left it, is now used in all our flour mills, in all of the grain elevators which mark the railroad stations in our great Western wheat country, and the vast granaries of the railroad termini, with their capacity for holding millions of bushels: this system handles every grain of wheat from the time it leaves the wagon of the Western farmer, until it is packed, as flour in some gigantic Minneapolis mill, or stored in the hold of the trans-Atlantic steamer.

With regard to Oliver Evans' connection with the steam engine, this much we can safely say, that he early conceived the idea of using steam of high pressure, that he lost no opportunity to bring his views to the attention of those whom he thought could assist him in the realization of his hopes; that he built a successful steam engine in 1802; drove a heavy wagon by steam in 1805, and propelled a boat by steam-driven paddle-wheels the same year. That the type of engines he designed (small diameter of cylinder and long stroke) continued for many years the distinctive American engine. We see that he helped to overcome, by his personal exertions, the universal fear of high pressure steam, and introduced a type of engines which, by their lightness and cheapness, were fitted for the needs of a new settlement. But that he was the first man to conceive of the idea of using high pressure steam is scarcely probable; that he originated the locomotive is very doubtful. A Frenchman named Cugnot built a model high pressure traction engine in 1769, which ran for a time about the streets of Paris, until it upset, and was, with its inventor, promptly cast into prison. The next year he made a second, which is still in existence in Paris, and failed chiefly because its boiler was too small. In 1784, Murdock made a model high-pressure engine, and Watt in his patent put forth the idea of a steam carriage for common roads. This was two years before Evans applied for his patent in Pennsylvania. In 1800, Trevethick made an engine with beam, cylinder 19 inches

diameter, 5 feet stroke, and, in 1802, he took out his patents. There are certainly many points of similarity between the engines of Trevethick and Evans, but I do not think it is proved that the former copied the drawings of the latter, or even appropriated his ideas. It is much more likely that the two inventors, having the same goal before them, endeavored to arrive at it by the same means, or, as Oliver Evans says of another, "it frequently happens that two persons, reasoning right on a mechanical subject, think alike and invent the same thing without any communication with each other."

We can afford to grant a measure of merit to Evans's contemporaries without injuring his memory. He accomplished enough to establish his reputation upon a firm basis. What he might have done with better facilities and ample capital we can scarcely conjecture. My own opinion is that he underestimated the difficulty of building such a traction engine as he conceived possible, and from the fact that such engines are only now coming into anything like common use in this country, I fear that had he been permitted to carry out his ideas, the result would have fallen far short of his cherished expectations. We cannot but admire the pluck and determination with which he endeavored to develop his inventions, the courage with which he expressed his convictions. In the words of the late Mr. Joseph Harrison, Jr.: "*He*, with no misgivings as to the future, and with no dimmed vision, saw with prophetic eyes all that we now see. To him the present picture in all its grandeur and importance, glowed in broad sunlight."

And as was said by another: "Wherever the steam mill resounds with the hum of industry, whether grinding flour on * * the Schuylkill, or cutting logs in Oregon, there you find a monument to the memory of Oliver Evans."

MAGNESIUM FOR ILLUMINATION.—M. Graetzel has succeeded in producing pure magnesium by an electrolytic method, at a price much below the rates at which it has hitherto been sold. Serious thoughts have thus been awakened of employing it for ordinary lighting purposes. The Bremen factory of aluminium and magnesium, which uses Graetzel's processes, has just organized an exhibition for magnesium lamps with clock-work movements. Two prizes of $125 and of $50, will be awarded to the makers of the lamps, which shall be adjudged the best and the most practical.—*Ann. Industr. Cosmos, Aug. 24, 1885.*

THE APPLICATIONS OF ELECTRICITY TO THE DEVELOPMENT OF MARKSMANSHIP.

BY O. E. MICHAELIS, Captain of Ordnance, U. S. A.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *March 15, 1886.*]

Recent events with which you are all familiar appear to emphasize the correctness of the general belief that a soldier should be a man of action rather than a man of words. The question must then naturally suggest itself to you, why I have the temerity to appear before you this evening as a reader or talker. I gained so much information through my official connection with the Electrical Exhibition, and was treated with such extreme kindness and courtesy by its managers, that I esteem it a great privilege to be afforded an opportunity of showing my appreciation and gratitude by attempting to impart, as well as I may be able, such special knowledge as I am flatteringly supposed to possess. The general subject of the application of electricity to warfare has already been exhaustively treated by my able colleague, Lieutenant Fiske, of the Navy, and my distinguished friend, Professor Abbé, has a prescriptive right to the "Signal Service Electrical Methods," hence my subject had to be special, and I determined to attempt to investigate the influence of electricity in the development of the science of gunnery, by briefly sketching the origin and expansion of our knowledge of the flight of projectiles, and by showing the astonishing facility and accuracy attained in this necessary investigation by the introduction and use of electrical apparatus.

Probably many of you who are present saw a year or so ago that unique exhibition called the "Wild West," and were astonished by the marvellous shooting of "Buffalo Bill." You may possibly have as souvenirs half-dollars hit by him in mid-air, at the distance of about thirty feet. In the execution of this apparently wonderful shooting, he used a Winchester repeating rifle, with a charge of thirty grains of powder, and a bullet weighing 200 grains. His mark, a silver half-dollar, was 1·2 inches in diameter. Now please keep in mind, Buffalo Bill's distance, thirty feet, and his mark, 1·2 inches in diameter. Marksmen, both in the National Guard and in the Army have made ten consecutive bull's-eyes at

1,000 yards, using charges of 100 grains or over, and bullets weighing 500 grains.

Let us compare this performance with Buffalo Bill's striking exhibition. The bull's-eye at 1,000 yards is three feet in diameter;

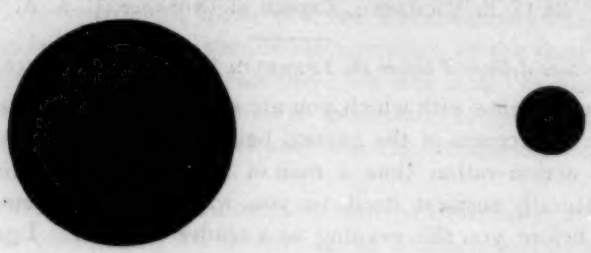

FIG. 1.—Silver Half-dollar. 1,000 yd. "bull's-eye," as seen at 10 yds.

this reduced to ten yards would be $\frac{36}{100}$ of an inch, $\frac{3}{10}$ths the size of the silver half-dollar. It is true the silver half-dollar was a moving object, but when you consider its low velocity and its comparatively large size, the feat is not so difficult as the clean score of the military shot. The latter, too, has to contend with both the moral and physical effect of severe recoil, with wind effect or deviation, with the diverting influence of the projectile's rotation or drift, and, in fact, with all cumulative atmospheric influences. If you will remember that the minutest error at the firing point produces most exaggerated effects at the distance of the target, 1,000 yards, you will agree that making bull's-eyes at this distance must be the convergent result of correct judgment, dauntless nerve and abstruse science.

The first two are personal qualities, inborn or acquired; the latter is exhibited in the development of the arm and projectile, and in the manufacture of the propelling agent, *gunpowder*.

It would be exceedingly interesting to investigate the moral causes that tend to make individuals good marksmen. We would find ourselves involved in an absorbing ethnological study, and would soon be convinced that the same race-qualities that brought about religious freedom, the writ of *habeas corpus*, and trial by jury, are also necessary concomitant elements in the growth of national good-marksmanship. But for the purposes of this paper, we must assume that the man who points the gun has all the requisite attributes of mind and body that characterize the good shot. I may say, however, that the general interest and

great improvement in target practice in this country during the past decade is, in great measure, due to the establishment of Creedmoor, to the energy and enthusiasm of General Geo. F. Wingate, and, so far as the army is concerned, to the excellent manuals of Laidley and Blunt. It would also be instructive to study the evolution of the weapon from the earliest match-lock, through wheel-lock, flint-lock, percussion-lock, to the present accurate long range rifle; from the Ho-pao, the Chinese fire-gun, to the gigantic sixteen-inch Krupp breech-loader, dwelling, in passing, upon the remarkable prophecy of Benjamin Robins, published in 1747, and fulfilled in the brilliant Italian campaign of 1859.

"I shall, therefore, close this paper with predicting that whatever state shall thoroughly comprehend the nature and advantages of rifled barrel pieces, and, having facilitated and compleated their construction, shall introduce into their armies their general use with a dexterity in the management of them; they will by this means acquire a superiority which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms, and will perhaps fall but little short of the wonderful effects which histories relate to have been formerly produced by the first inventors of firearms."

But, again, for our purpose this evening, we must take the results of this investigation for granted, and assume that our ethnologically developed marksman is armed with the scientifically evolved weapon.

There remains, then, the consideration of the propelling agent still, up to this late period of the nineteenth century—*gunpowder*.

Accurate results are produced by controllable causes.

Accurate shooting is within limits a direct function of the man, the gun and the powder. The man and the gun being assumed, it follows that to assure uniform results we must have uniform powder.

While on duty in the West, travelling in Montana, Dakota, etc., I have several times met fine shots without any scientific knowledge, who, when I asked them what allowances they made for disturbing influences, replied that they aimed "about thar," and in so doing they hit. This reply is their unconscious confirmation of what I have just stated, that to assure uniform results we must have uniform powder; for experience has given them

the personal equation of man, gun and ammunition, and it is the constancy of these components that produces the accurate result.

And a brief investigation of one of the modern means of controlling this essential uniformity of the product of our powder mills is the gist of this evening's paper, and enables me to show you that this branch of scientific inquiry was not improperly accorded a place in the great International Electrical Exhibition of the FRANKLIN INSTITUTE.

Gunpowder, as is well known, is a mechanical mixture or incorporation of nitre, sulphur and charcoal. To produce the best results, these substances must be refined, pure. Special care, the reward of long experience (our own most famous makers have been for generations in the business), is required in the admixture of these ingredients. Certain volumetric and gravimetric densities, specific weights and granulations, are best adapted for given required effects, and I wish it were within the scope of this evening's paper to tell you how these are observed and controlled. The tendency of modern progress has been to leave the manufacturer unhampered as to quality of ingredients or method of treatment, and, instead, to demand of him a powder that shall yield a certain *definite* result. This result is measured by the expressed *power* of his product, determined by its effect upon the arm and the projectile. The former is called pressure, the latter velocity. In reality, these are not distinct manifestations of power, for did we know the velocity of the projectile at every point within the barrel, the effective pressure at these points could be deduced. The magic mixture, simulating thunder and lightning in its ignition, which drove Roger Bacon from Oxford, the detonating compound with which Berthold Schwartz armed European feudal chivalry to its own destruction, was a very different thing from the mighty, controllable agent produced at present upon the banks of our historic Brandywine.

This great development has been brought about by the methodical observance of expressed effects, and has culminated to-day in our ability to control these effects.

As has been said of one of the greatest of Philadelphians, we have chained the lightning, and to tell you briefly how this has been brought about is my main object to-night.

Benjamin Robins, Fellow of the Royal Society, is the founder

of the modern scientific method of investigating the force of fired powder. His work, "New Principles of Gunnery; Containing the Determination of the Force of Gun Powder, and an Investigation of the Difference in the Resisting Power of the Air to Swift and Slow Motions," was first printed in 1742.

For this, and for subsequent papers on the same subject, read before the Royal Society, in 1746 and 1747, he received its gold medal. In presenting the medal, the President made an address, from which I quote, simply to show the contemporaneous opinion of Robins's work.

"It is from these experiments, and from those others which Mr. Robins is still preparing to exhibit that we may expect to see compleated the whole, and the true theory of projectiles.

"What Galileo and Torricelli, who first demonstrated the motions of these bodies *in vacuo*, knew to be still wanting in their theories, will hereby be supplied, and these particulars will at last become known, which they wished that future observers would make diligent and careful experiment about. The great Sir Isaac Newton, who did so much honour when living, not only to this Society and to this Chair; not only to this country and to the age he lived in, but to the world in general, and to human nature itself; this great man, I say, in his admirable 'Principia,' investigated the laws of the resistances made to bodies in motion, during their passage through the air and other fluids, and those upon different theories, and upon different suppositions.

"He also made experiments upon the resistance given to funipendulous bodies in their oscillations, and to others in their fall, which he caused to be dropped for that purpose from the highest part of the cupola of St. Paul's Church; but he never had the opportunity of making trials upon those much greater resistances, that shells and bullets are impeded by, in those immense velocities with which they are thrown from military engines. And hence it has come to pass that succeeding writers, even those of the first class, and who are the most justly distinguished by their great knowledge and abilities, not sufficiently attending to the true theory of these motions, have been of opinion that in large shot of metal, whose weight many thousand times surpasses that of air, and whose force is very great in proportion to the surface wherewith they press thereon, this opposition is scarce discernable, and

as such may, in all computations concerning the ranges of great and weighty bombs, be very safely neglected. This is one of those principles which the learned gentleman, who favored us with these experiments, very particularly proposed to examine, and that both theoretically and practically."

A recent author thus speaks of this profound experimenter:

"Benjamin Robins, the eminent scientific English artillerist, whose researches and experiments, conducted with such remarkable ability, skill and perseverance, effected so much and led the way for the introduction of the more recent improvements in gunnery, died in the year 1751. His able works continue to be regarded as possessing the highest authority."

I have already given you a glimpse of his prescience by quoting his prediction regarding rifled arms. Almost every great modern improvement in artillery science is foreshadowed in his writings.

Almost to the middle of the sixteenth century, projectiles were supposed to move in right lines. Tartaglia, in 1537, first attempted to reason concerning the form of a projectile's path, and came to the conclusion that the trajectory was made of three parts, a straight line, an arc of a circle, and another straight line. One hundred years later, Galileo printed his dialogues on motion, in which he pointed out the general laws of motion, and first described the action and effect of gravity upon falling bodies. From these investigations he determined that the trajectory of a projectile *in vacuo* was a parabola. Our personal observation and experience would naturally lead us to assume our atmosphere as a very type of non-resisting fluids, and hence we are not qualified to estimate the enormous force it opposes to bodies moving through it with great velocity.

Galileo experimented with slowly moving bodies, to which the air offered but slight resistance, and while aware of its existence, he considered its effect insignificant.

The crude ideas that artillerists had relative to the path of a fired projectile were abandoned, it was assumed that all projectiles moved in parabolic curves, and that the resistance of the air on account of the enormous relative weight of the "mobile" could have no appreciable effect upon its flight. These views were maintained in England, by Anderson, "Genuine Use and Effects of the Gunne," 1674, in France, by Blondel, "Art de jetter les Bombes,"

1683, and also by Dr. Halley, in the "Philosophical Transactions" of 1686. Notwithstanding Newton's warning, given in the "Principia," in 1687, confirmed by Huygens in 1690, notwithstanding Ressous's utter skepticism announced before the Academy in 1716, these erroneous views were held almost universally until overthrown by Robins's experiments.

This scientist saw that he must show an agreement between theoretical and practical results in order to establish his theories as facts, and to accomplish this, he invented, to use his own words, "a new method of finding the real velocity of bullets of all kinds," and this apparatus, described in 1742, was the first practical velocimeter. Attempts had been made before this time to determine the velocity of projectiles; the time of flight over a given space had been observed, and the velocity deduced therefrom, of course with an accidental error of anywhere from 200 to 600 feet per second.

Again the range at a given elevation had been measured and the velocity calculated on the parabolic theory, fallacious in result, as we now know, on account of the resistance of the air.

Powder was "proved" by means of the *eprouvette*, a method in vogue until comparatively very recent years. Colonel Louis De Tousard, an educated French artillery officer, who served as inspector of our artillery, and to whom I shall again refer, gives the following description of this method in his "American Artillerists' Companion," begun in compliance with the wishes of Washington, in the year 1795.

"In the proof of gunpowder, use is made of a brass mortar, called *eprouvette*, cast upon a bed of the same metal. The *eprouvette* points under an angle of 45° when the bed is horizontal. Its calibre is 7·52 inches, and projects a solid globe of copper weighing sixty pounds. Formerly three ounces of new powder projected this globe 180 yards; remanufactured powder 160. At this time 3 ounces 53⅜ grains of new powder must carry this globe 216 yards. The same quantity of remanufactured powder must carry the globe 185 yards. The *eprouvette* is the most exact firearm we have, because its ball has little windage, and because it consequently receives a less lateral direction, which may turn it from the direct course; besides the inflammation acts upon it with all the force of which it is susceptible, since very little of the elastic fluid escapes round the ball."

Before describing Robins's method of determining the velocity, I will anticipate for a moment, and tell you of the principal attempts made on the Continent in continuation, possibly in evasion, of his experiments. In 1767, Mattei, an Italian instrument maker contrived a machine for determining velocities. It consisted of a vertical paper cylinder mounted in a wooden frame, and made to rotate by means of a cord and weight. A uniform, known speed having been attained by it, the projectile was fired through it, perpendicularly to the axis, and the position of the resulting two holes in the surface gave the arc through which the cylinder had rotated during the passage of the bullet. It was assumed that the ball traversed the cylinder with a uniform velocity, and it is apparent that the precision of the results is a function of the diameter of the cylinder, and of the rapidity and uniformity of its revolution.

The probabilities are that this machine could not measure less than the one-thirtieth of a second, during which period a modern projectile covers from forty to seventy feet. That "there is nothing new under the sun" is well illustrated by these early devices for measuring initial velocity. Mattei's machine is the prototype of a large class of modern instruments for noting minute time intervals between consecutive events. I refer to the use of a uniformly rotating cylinder. A notable example is the astronomical chronograph. For the very small intervals required to be observed in ballistic investigations, this principal is not reliable, for we cannot depend upon the fractional uniformity of rotation of the cylinder. The ingenious, simple, and accurate measure in which this objection has been overcome will be seen later.

In 1804, Colonel Grobert, of the French army, introduced an important modification of Mattei's device. The cylinder was reduced to its heads, and the axis was made horizontal. That is, two discs of card-board about 6½ feet in diameter, were mounted on each end of a horizontal shaft about 13 feet long. These discs were divided into 360° by radii lying in the same meridian plane, and were similarly graduated. An endless chain in combination with a windlass and fly wheel produced rotation, which was timed after having become apparently uniform. The piece was fired parallel to the axis through both discs. You can readily see that here, as in Mattei's machine, the duration of the trajectory between the discs was given by the angle of revolution.

This apparatus depended for its precision upon the same, then almost impossible, conditions that Mattei's required. Even this modified cylinder apparatus has apparently been revived in one of the latest English chronoscopes, which is thus described in part: "The mechanical arrangement of the instrument consists of a series of thin metal discs each thirty-six inches in circumference, fixed at intervals upon a horizontal shaft, which is driven at high speed by a heavy descending weight."

The next important step was taken by another French officer, Colonel Dabooz, who, in 1818, contrived a gravity apparatus for measuring initial velocities. At fifty yards from the gun, he placed a fixed screen, immediately in front and above this, he suspended another screen, hung by a cord, which passed over pulleys, and was stretched by a balancing weight in front of the

FIG. 1½.—Dabooz's Method of Determining Velocities.

muzzle of the gun. The projectile cut the cord, the movable screen fell, and both it and the fixed screen were perforated at the same instant. The relative distance between the holes gave the duration. Of course, you see that the main error here is due to the fact that the movable screen does not fall at the instant the restraining cord is severed. I will show you presently how this very correct principle has been applied in late years, and how very elegantly and completely this instrumental and accidental error has been eliminated.

Many other variations of these devices for measuring the velocity of projectiles were suggested and tried, but finally the method of Robins was generally adopted by military powers. In a few words, Robins proved that the parabolic theory, as applied to projectiles with low velocities, was not far out of the way, but that when

applied to rapidly moving bodies, it was utterly false, and that the fallacy was principally due to the resistance of the air, and that this resistance increased with enormous rapidity with the increase of velocity.

I will now describe the apparatus by which, in the main, he laid the foundation of modern gunnery. You all know what influence "handicapping" has upon the speed of race horses. Robins handicapped his swiftly moving projectiles until their speed was reduced within the scope of his instrument, and then, knowing the exact influence of his added weight, of course the original velocity became known. In explanation, to use our school-day terms, if one body strike another, the momentum lost by one is gained by the other, but the total remains unchanged.

Dependent upon this principle, Robins constructed his *Ballistic*

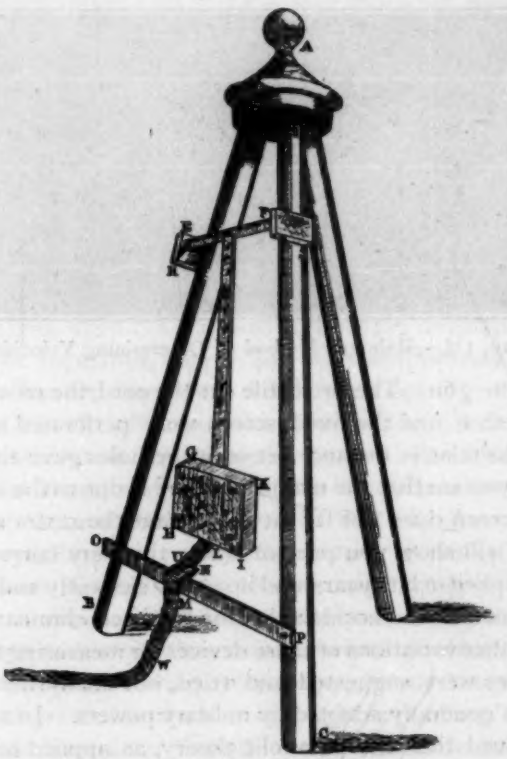

FIG. 2.—Robins's Ballistic Pendulum.

Pendulum—the instrument before you—to gunnery what the mariner's compass has been to navigation.

It is merely an iron pendulum, whose "bob" is faced with a thick piece of wood; to this a narrow ribbon is appropriately attached, which by "paying out" measures the extent of the vibration or swing.

The bullet is fired into the wooden block wherein it lodges; it imparts the whole of its motion to the pendulum, the resulting known momentum is equal to the momentum of the bullet at the instant of impact, and the velocity of the projectile is determined.

If W = weight of pendulum,
w = weight of projectile,
v = velocity of projectile,
V = velocity of pendulum

$$w\,v = (W + w)\,V,$$
$$v = \frac{W + w}{w}\,V.$$

The weight of the pendulum and the distances of its centres of gravity and oscillation must be known. The centre of gravity is readily found, directly by balancing the pendulum on a knife-edge, or indirectly, by bringing it to a horizontal position by means of a cord, fastened to the end opposite the axis, passing over a pulley, and carrying a compensating weight; for then the weight of the pendulum is to the suspending weight as the whole length of the pendulum is to the distance of the centre of gravity from the axis. The centre of oscillation, or that point where, if the whole mass of the pendulum were collected and suspended by a thread from the axis, the angular velocity would be the same under the same initial circumstances as that of the whole pendulum, or, in homely phrase, the "bob" of the corresponding simple pendulum is located by the formula $l = \pi^2 g t^2$. t is found by observing the time of a large number of oscillations.

Robins's pendulum weighed 56 pounds 3 ounces, its centre of gravity was 52 inches from the axis, and it made 200 "swings" in 253 seconds. Hence its centre of oscillation was 62⅔ inches from the axis.

The centre of the wooden facing, or "bull's-eye," was sixty-six inches from the axis, (in later constructions it was made coincident

with the centre of oscillation, and does not possess the property of the centre of oscillation) of moving under impact, precisely as would the whole pendulum. A correction must therefore be made. The *resistance to rotation* at this point must be exactly the same as at the centre of oscillation; or, in other words, the *moments* of *inertia* at the two points must be equal. The usual formula of Mechanics,

$$W k^2 = \Sigma w r^2,*$$

gives the weight to be considered at the centre of the bob, which, in this case, is 42 pounds ½ ounce. That is, the pendulum will resist movement when struck in the bull's-eye precisely as if *this* weight were concentrated there and the balance taken away. If a "twelve to the pound" bullet were fired, $\frac{1}{504}$ of forty-two pounds, the centre of oscillation will move with $\frac{1}{505}$ of the bullet's velocity of impact, whence, if its velocity be multiplied by 505, we have the velocity of the projectile. The length of ribbon "paid out" gives by reduction the chord of the arc of oscillation due to the impact of the shot, and as its radius is given, we know the versed sine, which is the perpendicular height through which the centre of oscillation has moved, and the *time*† in which it has attained this height is, of course, the same as if it had freely *fallen* through this distance. Therefore, the time and the space being known, the velocity is also known. Robins considered the precision of his device very great. In his own words: "In a bullet moving with a velocity of 1,700 feet per second, the error in the estimation of it need never exceed its $\frac{1}{100}$ part."

For over 100 years, a period that included great revolutions and wondrous campaigns, nothing practical was done in this branch of investigation, the complete record of the power of one of the mighty agents of progress, except a studious following in

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* k, the radius of gyration, is a mean proportional between the distances of the centres of gravity and oscillation from the axis, hence

$$k^2 = 52 \times 62\tfrac{4}{5},$$

but k is also the length whose square is the mean of the squares of the distances of the elementary equal masses from the axis, hence the above equation, from which $\Sigma w = 42{\cdot}03$ pounds.

† $t = \sqrt{\frac{2h}{g}}$

the footsteps of Robins, except the elaboration and development of the Ballistic Pendulum. As evidence of the slow and guarded growth of this only correct method of determining the force of fired powder, the true basis of modern ballistic science, I will again quote from De Tousard's "American Artillerists's Companion," published in 1810. In his Introduction, the author says: "Artillery had its infancy in common with all other sciences, but its progress toward improvement was much slower. Let us not be guilty of the reproach cast [heretofore] on military men [their dislike to innovation], but let us rather endeavor to enlighten ourselves by taking advantage of the experiments and information of all the military and well-informed nations of Europe. Let us not return to those times in which artillerists believed in the rectilinear motion of projectiles, and afterwards in the parabolic motion; lest, like them, we may be obliged, after two or three centuries, to abandon these absurd opinions. Benjamin Robins shall be our guide."

And yet in the two bulky volumes of this work not a word is said of the Ballistic Pendulum. This distinguished officer, well educated for his time, writes thus: "The *initial velocities* of shot and shells must be indispensably known before the problems in projectiles can be solved, which are determined from experiments made with skill and discernment, and conducted with care and circumspection; first, by measuring their penetration into a homogeneous, but of a known consistency; second, by analyzing and resolving into its simple movements the curve described by the projectile on quitting the piece; third, by deducting it from the thickness of metal of the firearm when it is in equilibrio with the pressures of the elastic fluid in every point of its length."

What this means I do not know, and I don't believe the author knew, either.

In another place De Tousard says: "For the moment, we will only mention that it appears at least extremely difficult to find, either by theory or by experiments, the initial velocity of a ball at its quitting the gun; and that the numerous and unconquerable difficulties which present themselves in the solution of this problem must cause it to be looked upon as nearly impossible."

I can reconcile these later utterances with the tribute to Robins in the Introduction, only on the assumption that during the

interval the patriotism of the author of the "American Artillerists's Companion" asserted itself, and that he rejected the entire groundwork of modern accurate practice because it was "English," not a tenable reason nowadays.

Once, while walking in the cemetery at Munich, I came upon a stone graven with the simple words, *Frauenhofer—approximavit sidera*, a complete record of his life-work. With equal terseness may we summarize Robins's labors, "He made shooting a science."

Charles Hutton began at Woolwich, in 1775, his "New Experiments in Gunnery," for which he received, as had his predecessor, the gold medal of the Royal Society.

In his works, Tract 34, he writes: "The object of those experiments was the determination of the actual velocities with which balls are impelled from given pieces of cannon, when fired with given charges of powder. They were made according to the method invented by the very ingenious Mr. Robins, and described in his treatise on the 'New Principles of Gunnery,' of which an account was printed in the 'Philosophical Transactions' for the year 1743. Before the discoveries and invention of that gentleman, very little progress had been made in the true theory of military projectiles. This book, however, contained such important discoveries that it was soon translated into several of the languages on the continent, and the late famous Mr. L. Euler honored it with a very learned and extensive commentary, in his translation of it into the German language. That part of Mr. Robins's book has always been much admired, which relates to the experimental method of ascertaining the actual velocities of shot, and in imitation of which, but on a larger scale, those experiments were made which were described in my paper. Experiments in the manner of Mr. Robins were generally repeated by his commentators and others, with universal satisfaction; the method being so just in theory, so simple in practice and altogether so ingenious, that it immediately gave the fullest conviction of its excellence and the eminent abilities of the inventor. The use which our author made of his invention, was to obtain the real velocities of bullets experimentally, that he might compare them with those which he had computed *à priori* from a new theory of gunnery, which he had invented, in order to verify the principles on which it was founded.

"The success was fully answerable to his expectations, and left no doubt of the truth of his theory, at least when applied to such

pieces and bullets as he had used. These, however, were but small, being only musket balls of about an ounce weight; for, on account of the great size of the machinery necessary for such experiments, Mr. Robins and other ingenious gentlemen, have not ventured to extend their practice beyond bullets of that kind, but contented themselves with ardently wishing for experiments to be made in a similar manner with balls of a larger size. By the experiments described in my paper, therefore, I endeavored in some degree, to supply that defect, having used cannon balls of above twenty times the size, or from one pound to near three pounds weight. These are the only experiments that I know of, which have been made in that way with cannon balls, though the conclusions to be deduced from such a course are of the greatest importance in those parts of natural philosophy which are connected with the effects of fired gunpowder; nor do I know of any other practical method besides that above, of ascertaining the initial velocities of military projectiles, within any tolerable degree of the truth, except that of the recoil of the gun, hung on an axis in the same manner as the pendulum, which was also first pointed out and used by Mr. Robins, and which has lately been practised also by Benjamin Thompson, Esq., (now Count Rumford), in his very ingenious set of experiments with musket balls, described in his paper in the 'Philosophical Transactions' for the year 1781. The knowledge of this velocity is of the utmost consequence in gunnery; by means of it, together with the law of resistance of the medium, everything is determinable which relates to that business; for, as remarked in the paper above-mentioned on the first experiments, it gives us the law relative to the different quantities of powder, to the different weights of balls, and to the different lengths and sizes of guns; and it is also an excellent method of trying the strength of different sorts of powder. Besides these, there does not seem to be anything wanting to answer every inquiry that can be made concerning the flight and ranges of shot, except the effects arising from the resistance of the medium." Hutton first developed the *Gun Pendulum*, just alluded to, and used it in conjunction with the Ballistic Pendulum. The gun to be fired is suspended as a pendulum, and the observation of the arc of recoil enables us to determine the velocity of the projectile, from the simple axiom that action and reaction are equal and contrary. The weight of the ball is to the weight of the gun, as the velocity of the gun is to the

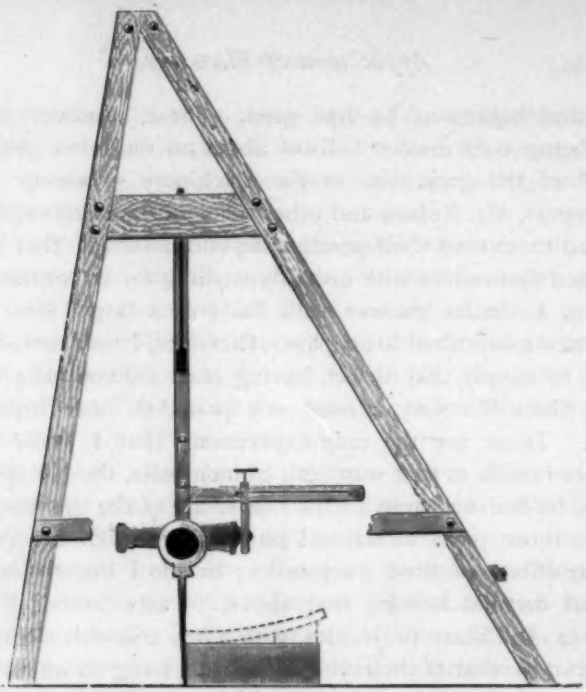

FIG. 3.—Hutton's Gun Pendulum. Side View.

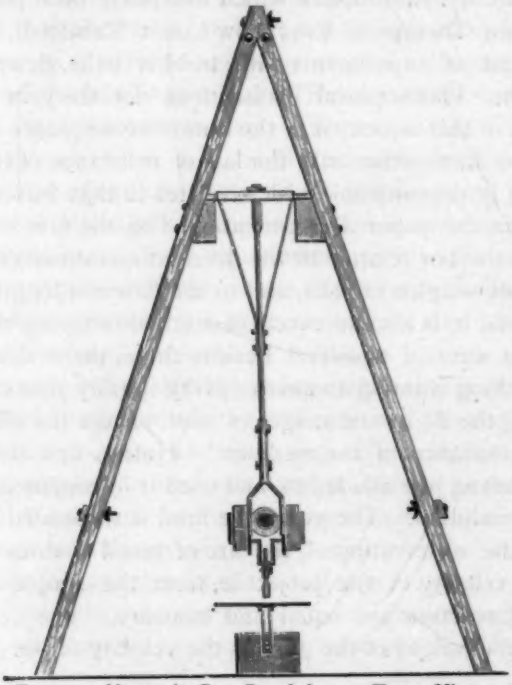

FIG. 4.—Hutton's Gun Pendulum. Front View.

velocity of the ball, provided the weight of the powder has had no effect upon the recoil. Hutton's pendulum weighed 700 pounds, and its centre of gravity was six and two-thirds feet from the axis of suspension.

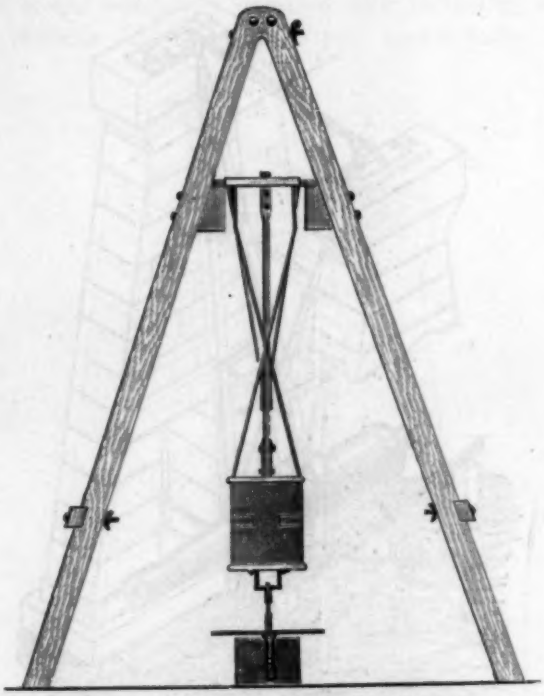

FIG. 5.—Hutton's Ballistic Pendulum.

As stated by Hutton, the objects of these experiments, extending from 1775 to 1790, were the investigation of every circumstance necessary to be known for the improvement of artillery, and, he adds, "The effects of most of these circumstances are determined by the actual velocity with which the ball is projected from the mouth of the piece." The capacity of the Ballistic and Gun Pendulums was gradually increased. At Metz, in 1839 and 1840, twenty-four pounder guns were "slung" and fired, but progress finally culminated in the structures erected at Washington Arsenal, where, from 1842 to 1847, a most exhaustive series of experiments were conducted by Major Alfred Mordecai, a distinguished officer, who has been for many years, and is now, an honored resident of

this city. He experimented with guns as large as thirty-two pounders, weighing about 7,700 pounds; his Ballistic Pendulum weighed over 9,300 pounds, and its centre of gravity was over fourteen feet below the axis of suspension. Mordecai's work,

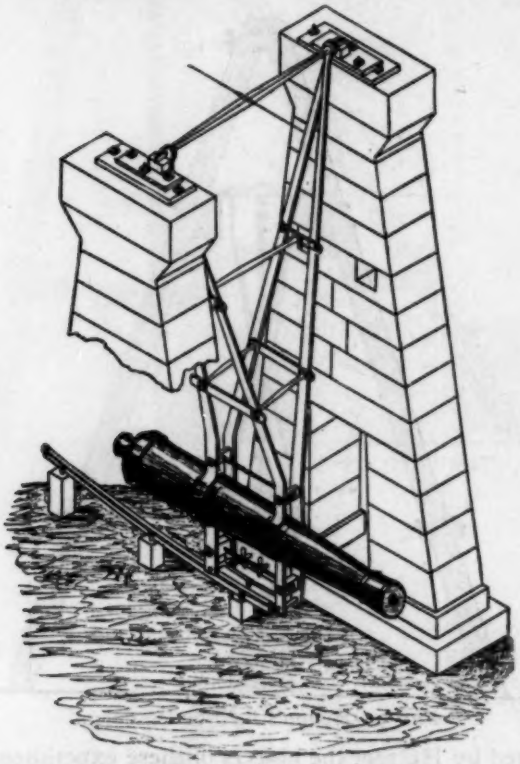

FIG. 6.—Mordecai's Gun Pendulum.

"Experiments on Gunpowder," is classic, and his conclusions cover, amongst others, the following points:

The proof of gunpowder;
Hygrometric tests;
Proportions of ingredients;
Mode of manufacture;
Density;
Size of grain;
Charges for cannon and small arms;
Cartridges for cannon;
Windage of balls;

Loss of force by vent;

Effect of wads, etc.

Major Mordecai reached the practical limit of the performance of the Robins apparatus. You have seen how rapidly the weight and length of the pendulum increased with increasing weight of projectile—Robins, fifty-six pounds per ounce balls; Hutton,

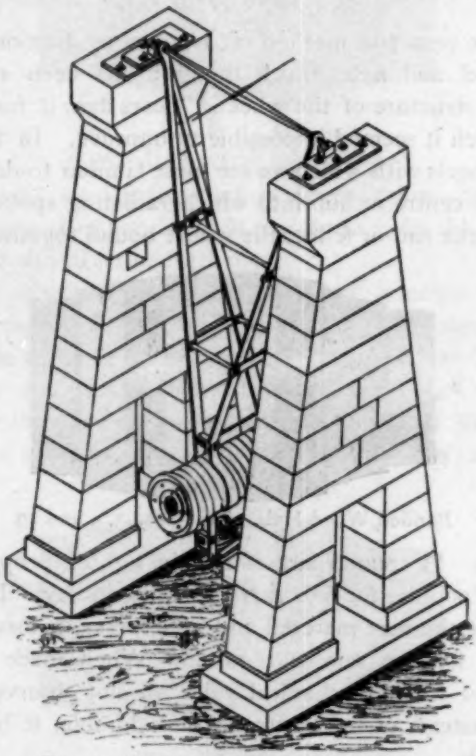

FIG. 7.—Mordecai's Ballistic Pendulum.

700 pounds for three pound balls, and Mordecai 9,400 pounds for thirty-two pound balls. To determine the velocity of a modern 1,000 pound projectile fired from a 100 ton gun, by this method, we should have to ask Colonel Roebling to build available Brooklyn Bridge towers, between which to swing our pendulums.

As late as 1851, Sir Howard Douglass, a distinguished authority, in his well-known "Naval Gunnery," mentions no other method of determining initial velocity than by means of the Robins pendulum.

(*To be continued.*)

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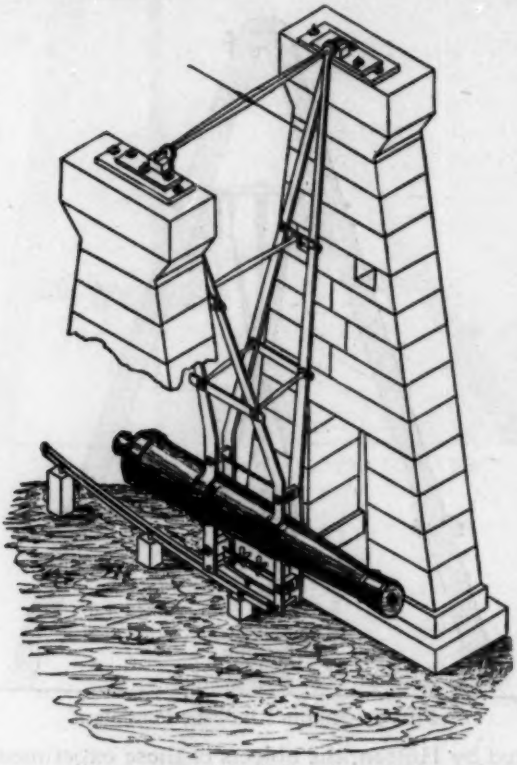

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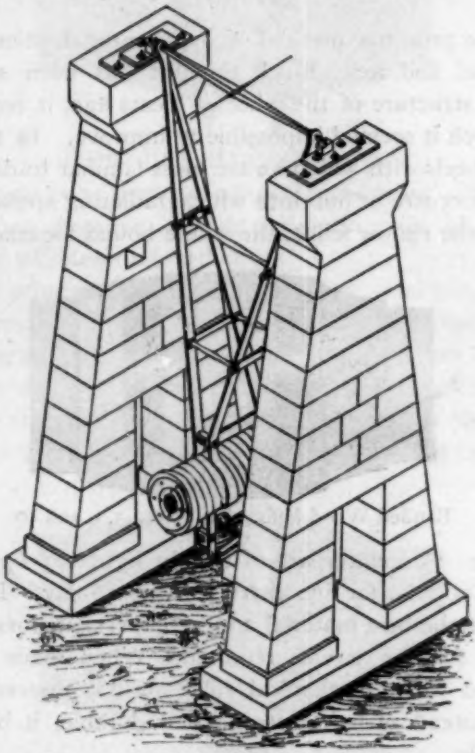

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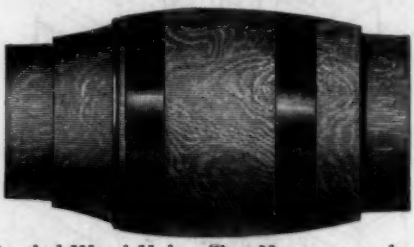
(*To be continued.*)

TESTS OF VEHICLE WHEELS.

By Howard M. DuBois.

[*A Paper read before the* Franklin Institute, *at the Stated Meeting, May 19, 1886.*]

Since the primitive method of overcoming friction by the use of the wheel and axle, much thought has been spent on the mechanical structure of the wheel. Years ago, it reached a point beyond which it seemed impossible to improve. In this shape we have the wheels with which we are most familiar to-day, consisting of a wooden centre or hub into which radiating spokes are driven, supporting the rim or felloe, the whole bound together by a metal

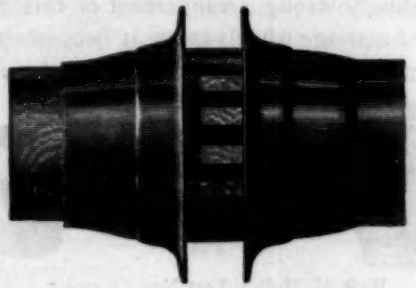


Banded Wood Hub. Test Nos., 3, 9 and 10.

band or tire. A counterpart of this in lighter proportion is the wheel most popular for fine carriage work to-day. In this shape and made of the best material and by experts it possesses all that is requisite for the service required. When made from poorer material and when mechanical rules are not observed in its construction instead of being strong and durable, it becomes soon unserviceable.

As the roads of our country are not all smooth and easy riding, it soon became evident that something more lasting and of stronger construction was necessary, and many different forms were invented. As all of these refer to the placing of the spokes in the hubs, we will briefly review the various principles involved. First, we have what is termed the Sarven principle, so named from its inventor. This consists of a series of spokes driven into a small wooden core and mitred to form a solid arch of wood around this core. Against the back and face of these spokes, a metal flange is

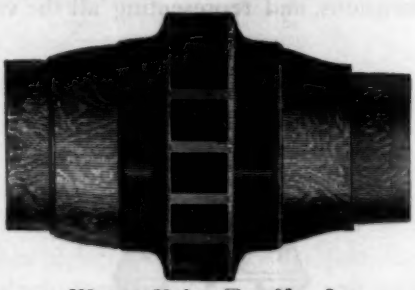
forced by hydraulic pressure and securely riveted, forming what would seem an indestructible wheel. But in practice this wheel



Sarven Hub. Test Nos., 2 and 6.

develops several peculiarities, and while the wheel itself was undoubtedly made stronger, it made the strain upon the axles more severe, as we will describe further on.

A second principle is called the Warner principle, also named from its inventor. This consists in driving the spokes through a metal mortise ring into a wooden hub. This was also a mechanical device more strong than the plain wooden hub wheel first described; but this, while not being so rigid and stiff as the Sarven, still conveyed the vibration of rapid motion to the carriage body,



Warner Hub. Test No., 8.

and the fact also was manifested by the more rapid wearing of the tires and rims than was the case under the older conditions. After years of trial both these systems have been condemned for carriage wheels, while steadily increasing in popularity as wheels for conveying merchandise and heavy burdens.

The latest form of construction for carriage work, the invention of Mr. Jared Maris, of Columbus, O., is called the "B. S. B," or Brown's shell band wheel, and consists of a metal shell from which

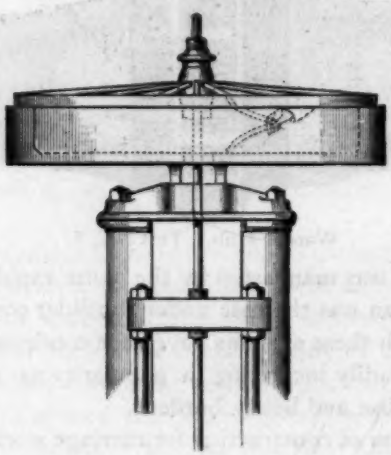
projecting ribs enter the hub, and form a solid metal wall, the spokes entering the hubs thus protected at their full size, this being an exceedingly strong arrangement of this part. With so many varieties of carriage wheels in use, it becomes almost a necessity to have some kind of scientific test made whereby an accurate

B. S. B. Hub. Test Nos., 1 and 5.

idea might be obtained of the carrying capacity of the various dimensions of wheels, and also that some of the reasons might be made clear why wheels made in one way should not produce the same satisfactory results as in some other form. With this end in view, the writer was selected by several of the largest manufacturers of wheels in this country to conduct an exhaustive series of tests for this purpose.

HOW THESE TESTS WERE MADE.

Having received an assortment of wheels, all uniform in size and general dimensions, and representing all the various kinds of



Attachment to Testing Machine.

vehicle wheels in common use, after due consideration it was decided that each specimen should be tired as for regular travel and subjected first to a test of the amount of weight it would take to "dish" the wheels backward one and one-fourth inches, this being the extreme practical limit, or the point at which the tire ceases to be a factor. After reaching this point, the wheels were to be released from pressure and a measurement made to see with what amount of elasticity the wheels returned to their normal condition. After this, upon a second application of pressure, it was thought to establish some point where wheels sustained rupture or became wholly useless.

To determine these points, the testing machine of Messrs. Riehlé Bros. was secured, this elaborate weighing machine being the one adopted by the United States Government as a standard. To adapt this machine for specimens so large as carriage wheels four feet in diameter, required a special face plate or casting just

One of each Main Division of Test of Wheels into Dish to determine Elasticity.

No.	1	2
Style of Wheel.....	B S B	Sarven.
Original Dish.....	½	$\frac{7}{8}$
Number of Spokes.....	14	16
Pressure into dish @ ¼ in.	330	400
" " ½ "	570	620
" " 1 "	730	900
" " 1¼ "	1050	1150
After pressing into dish 2 inches, Wheel returned to.....	⅜	1⅛

the diameter of the wheel, which was made with a raised rim or edge four inches higher than the face. Upon this rim or edge the wheels were placed face downward, and a bolt with a broad washer was placed through the centre of the wheel, and to the bolt the pulling strain was applied, the weight to the fraction of a grain being recorded upon the balance scale rod below.

Each specimen so tested was labelled and numbered, the accompanying diagram giving the weights and figures as taken.

WHAT THE TESTS DEVELOPED.

These tests developed the fact that wheels are arbitrarily divided into two grand divisions, namely, those having spokes driven in

straight lines, and those whose spokes are stepped or staggered. To make this more clear, we will state that resistance to pressure alone is not all that is required in a carriage wheel. Were this the case, the solid circle cut from a single piece would lead the tests. The most important factor in a carriage wheel is elasticity, or power to dissipate jar and vibration without conveying the same to the axles and springs, just as some substances are better conductors of heat and electricity, so some forms of constructing wheels are better or worse conductors of vibration. These tests prove then that all wheels in which the spokes are staggered, possess the power to resist strain and return to their normal condition, while those belonging to the other grand division, or those having the spokes standing in a straight line, while resisting pressure almost equally, do not return; or, in other words, do not possess the proper amount of elasticity to fit them for carriage purposes.

Again, we find this question of elasticity is affected to a great extent by the amount of free space between the hub and the rib of the wheel. We find in those wheels that the iron projecting above the hub clamps the wood of the spoke, stiffening the same until the vibrations are shortened, thus accounting for the more rapid crystallization of the steel in the axles used with these wheels than where the B. S. B. or plain wood hub is used. For ordinary use in the carriages, the B. S. B. wheel can be highly recommended, as these tests prove that it possesses, (1), an indestructible hub; (2), it has the same amount of free space between the hub and rim as the plain wood hub, insuring the same ease of motion and freedom from vibration; and, above all, it can be made durable without the close grading of material so necessary to success in the plain wood hub wheel.

These tests can be taken to form the basis of calculation, as the point at which the wheel comes straight or out of dish is nearly uniform, being 300 pounds. This shows that this proportion of spoke can only be depended upon to sustain a strain of 600 pounds, which is equivalent to the weight of two average persons swaying from side to side on springs, such as used on pleasure carriages. Taking these proportions then, we have a starting point from which we can proportion wheels to the loads they are to carry.

The tests were made to determine which of the wheels in common use were the best adapted to the requirements of the case, and

MR. HOWARD M. DuBOIS: PHILADELPHIA, March 30, 1886.

Dear Sir—We have this day tested for you specimens of Vehicle Wheels, with the following result: Test of Various Kinds of Vehicle Wheels in common use, made by Riehlé Brothers on Standard Machine adopted by U. S. Government.

STYLE OF WHEEL.	B. S. B.	Sarven.	Banded Wood Hub.	Wood Hub.	B. S. B	Sarven.	Maris Socket.	Warner.	Banded Wood Hub.	Band Wood Hub Compressed Tenon.
No. of Test.....	No. 1	2	3	4	5	6	7	8	9	10
No. of Spokes.....	14	16	14	14	14	16	14	14	14	14
Original Dish.....	½	½	½	½	½	½	½	½	½	½
Press're, lbs. 200	1/16	1/16	1/16	1/16	1/16	Straight	1/16	1/16		
250	1/16	1/16	1/16	1/16	1/16	back ½	1/16	1/16		
300	Straight	Straight	Straight	Straight	Straight	" "	back ½	Straight		
400	back ½	back 1/16	back 1/16	1/16	"	" "	"	back		
500	" "	" "	" 1/16	back 1/16	back ¼	" "	back ½	" "		
600	" 1/16	" ¼	" ⅛	" ⅛	" 1/16	" "	" "	" 1/16		
700	" ¼	" ⅛	" ⅛	" 1/16	" ⅛	" "	" "	" ⅛		
800	" ⅛	" ⅛	" ⅛	" ⅛	" ⅛	" "	" "	" ⅛		
850	" ⅛	" 1	" 1	" ⅛	" ⅛	" "	" 1	" ⅛		
900	" 1/16	" 1 1/16	" 1 1/16	" ⅛	" ⅛	" 1	" 1 1/16	" 1 1/16		
1000	" ⅛	" 1⅛	" 1⅛	" 1	" 1	" 1 1/16	" 1 1/16	" 1⅛		
1050	" 1	" 1 1/16	" 1 1/16	" 1 1/16	" 1	" 1⅛	" 1 1/16	" 1 1/16		
1100	" 1	" 1¼	" 1¼	" 1⅛	" 1	" 1⅛	" 1⅜	" 1⅛		
1300	" 1¼			" 1⅜	" 1¼	" 1¼	" 1½	" 1⅜		
Dish on 2d test after going back.....	" ½	" 3/16	" ¼	" 1 1/32	" ½	" ⅜	" 7/16	" 5/16	Back 5 in.	Back 5 in.
1 Returned to original Dish sound in every part .....2400 lbs.	Back 4 in. Press're	Back 4 in. Press're								
2 Sixteen Spokes drew from Hub.....2400 lbs.			Back 4 in. Press're	Back 3⅜ in. Press're						
3 Two spokes started from Hub and one split .....2000 lbs.					Back 5⅛ in. Press're	Back 4 in. Press're	Back 4 in. Press're	Back 2⅜ in. Press're		
4 Wheel collapsed, Hub split .....1950 lbs.										
5 Two spokes broke in Barrel, but sound in Hub.....2600 lbs.										
6 Rivets pulled and spokes broken.....2650 lbs										
7 One spoke started.....2200 lbs.										
8 One spoke broke and eight drew from Hub.....1550 lbs.										

1st Test.—From Original Dish to 1¼ in. back; then pressure relieved, to determine how near Wheels return to Original Dish.

2d Test.—Pressed Wheel back to 4 or 5 in. unless sooner broken.

No. 9 Three Spokes drawn from Hub and one started.

No. 10 Eleven Spokes drew from Hub. Tested to determine comparative holding powers of Tenons.

Wheel No. 5 was placed under pressure, with supports placed under Spokes at 1 foot from the Hub, and resisted a pressure of 3750 lbs., showing no breakage at Hub excepting one spoke drawn out.

RIEHLÉ BROTHERS.

our experiments show that the one, marked No. 1, withstood all the strain and was elastic enough to return to its normal condition, and we think possesses all that is required in a durable carriage wheel, the test showing it in percentage, at least ten per cent. in advance of all others tried.

DISCUSSION.

MR. ROBT. GRIMSHAW.—"Mr. President, I would like to ask if any tests were made of the amount of pressure required to make the outline of the wheel elliptical? As wheels are ordinarily used, there is a pressure placed upon the axle that tends to flatten the wheel; that is, make it out of round. It is very important in using wheels to know what their strength is. If wheels continue to flatten while in service, it will be a great deal harder to haul a load, and for such purposes where there is a very heavy load, the best wheel would be the one which would stand the greatest amount of dish in the manner explained by Mr. DuBois."

MR. DUBOIS.—"I think these tests have been made by Professor Morin, of Paris, but in carriage wheels we have always looked at the wheel tired as being almost a unit. That is, it is impossible to make it elliptical by any weight placed upon it, because it would break before reaching this point. I did make some tests, but did not have enough specimens to continue the experiments to make it more complete, and I propose to do that within the next few months. My remarks referred principally to carriage wheels in which the loads are never sufficient to make the wheel out of true."

MR. CYRUS CHAMBERS, JR.—"As I understand it, the tests are made by simply applying the pressure to the centre of the hub and supporting the rim uniformly throughout its circumference. That is not the strain upon a carriage wheel in practice. I think a very much better test would have been to have supported this wheel on an axle and applied this power to one edge of it."

MR. DUBOIS.—"I made some preliminary experiments in that direction, but found that with the tire on the results were so nearly uniform that there was no difference that I could detect. When the tire is placed on the wheel it limits the strain on the spokes. When the tire is put on, it is given a 'draft;' that is, it is put on hot, and as it cools off it draws the wheel into what we term 'dish,' and, in that shape, if we press the rim of the wheel with any lateral force it would effect the whole wheel. The tire would hold the whole wheel in shape and it would stand just about the pressure applied to it in these tests. I have the data, taken when these tests were made with the axle, and the results are almost uniform, but the experiments were not completed."

MR. CHAMBERS.—"I have made many tests with wheels, and would say that I can very easily take an elastic wheel, apply power to one side of it and make the side opposite to it take a position at angles to the axle. Do you wish us to understand that the more elastic wheel becomes the easier will it make the riding of the carriage? Do you think that elasticity is an important factor?"

MR. DUBOIS.—"Decidedly so."

MR. GRIMSHAW.—"Does not the elasticity of the wheel increase the traction of the carriage or vehicle, and will not a carriage with an elastic wheel be harder to haul than one with a rigid wheel, without regard to the ease of those in the vehicle?"

MR. DUBOIS.—"I think the draft might be increased by a wheel that was very elastic; it might assume a position in which it was at angles with the axle, in that case it would increase the draft. But provision is always made for this by setting the wheels, as it is termed, with 'gather.'"

COOLING OF CONDUCTING WIRES IN AIR AND IN A VACUUM.—A platinum wire, 50 centimetres long, and ·04 millimetres in diameter, was enclosed in a glass tube of six centimetres diameter, and traversed by a current of 1·18 ampères. In the open air, at ordinary pressure, the temperature of the wire did not exceed 75° C. On producing a vacuum of $\frac{1}{1900000}$ of an atmosphere, the wire became red hot. By delicate improved apparatus, Bottomley was able to produce and measure vacua of $\frac{1}{3000000}$ of an atmosphere. These results are interesting, for the prominence which they give to the necessity of obtaining as perfect a vacuum as possible in incandescent lamps. For equivalent currents, the temperature rises and the luminous efficiency increases in proportion as the vacuum becomes more perfect.—*L'Electricien, Sept. 26, 1885.*

UTILIZATION OF ATMOSPHERIC HEAT.—M. Tellier has laid before the French Academy a plan for the combined application of atmospheric heat, and of condensation by cold water for raising water from wells. The roof of a shed or small building is composed of tight compartments formed of sheet iron plates, which are riveted at their edges. In each of the compartments a volatile liquid is enclosed, which becomes vaporized by the atmospheric heat, the vapors escaping by tubes, which meet in a common reservoir. Whatever liquid is drawn with the gas, returns to the compartments by a lower tube. The vapor passes from the reservoir to a metallic sphere at the bottom of a well. This sphere has a caoutchouc diaphragm, which can be fitted by its elasticity alternately to the upper and lower hemisphere, so as to move a sliding valve, and by the alternate introduction and condensation of the vapor to raise water in considerable quantities. In one experiment, 1,200 litres per hour were raised from a depth of seven metres.—*Cosmos, Aug. 24, 1885.*

COLOR-SENSITIVE PHOTOGRAPHIC PLATES.

By Fred. E. Ives.

[*A Paper read at the Stated Meeting held May 19, 1886.*]

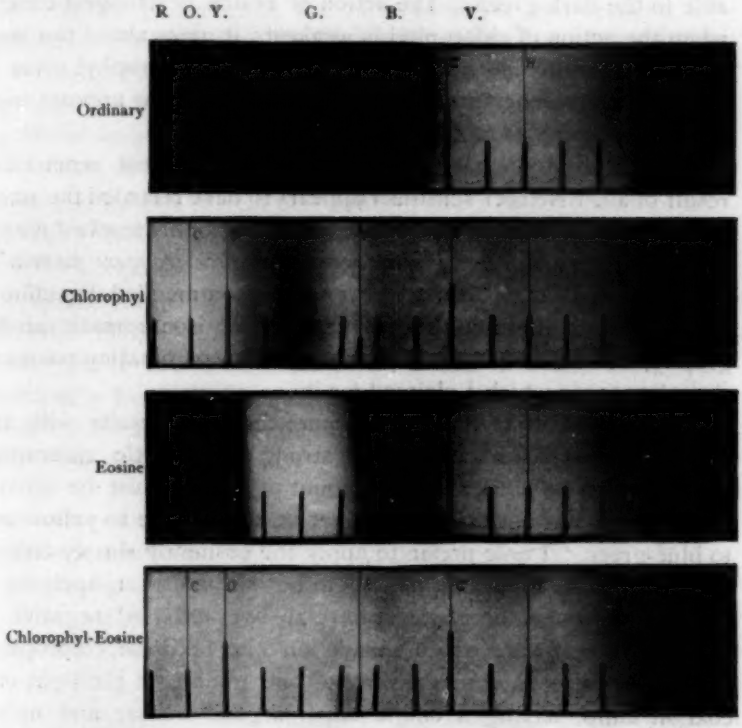
The subject of color-sensitive photographic plates has received a great deal of attention during the past year or two, but there has been and is still a great diversity of opinion in regard to the capabilities of the various color-sensitizers. In illustration of this fact, I will mention that Becquerel, who first tried chlorophyl, stated that with it he made plates from one-fifth to one-tenth as sensitive to the red of the spectrum as to the blue or violet; Dr. Vogel estimated that eosine-stained plates were eight times more sensitive to the yellow-green of the spectrum than to the blue; I myself stated that plates stained with myrtle-chlorophyl, according to my published method, required even less exposure through a yellow glass than eosine plates. Capt. Abney stated that, according to his experience, stained plates were always many times more sensitive to blue and violet than to any other color, and many persons have believed that the color-sensitizers acted more by reducing the blue and violet sensitiveness than by actually increasing the sensitiveness to other colors.

For the purpose of proving the capabilities of chlorophyl and eosine, I have made four photographs of the lime-light spectrum, one on a plain emulsion plate, one on a chlorophyl-stained plate, one on an eosine-stained plate, and one on a plate stained with both chlorophyl and eosine. The spectrum was projected by means of an optical lantern, and a flint glass prism, with a slit measuring one-fiftieth of an inch. It will be understood that the different colors have not exactly the same relative intensity in this spectrum that they have in the solar spectrum, but the difference is insignificant. Short wires were placed so as to cast shadows on the sensitive plate, to aid in the comparison of results; some of these wires, which I have marked, occupy the position of Fraunhofer lines in the solar spectrum. All plates were prepared with the same collodion bromide emulsion, and received the same exposure and development.

The plain emulsion plate shows very little action, except in the blue, violet and ultra-violet; the maximum of sensitiveness is in

the middle of the violet. (It should be noted here that with gelatine bromide dry plates, the maximum of sensitiveness is in the indigo blue, about *G*, and they are also relatively more sensitive to green and yellow.)

The chlorophyl plate shows a very strong action all through the visible spectrum, strongest in the red, orange and dark green; weaker in the blue and violet, and weakest in the yellow-green.



[Owing to the negatives being too intense to reproduce perfectly by the photo-typographic process, the strongest action in the color-sensitive plates appears relatively less in the illustration than it does in the original negative.]

In the red, below *C*, the plate shows about five times as much sensitiveness as in any part of the violet; in the orange-red, twice as much; in the yellow-green, one-half as much; and in the dark-green, one and one-half times as much. The violet sensitiveness appears to be slightly reduced near *H*. This experiment proves that my chlorophyl plates are remarkably sensitive to all colors, as

I have many times asserted that they were, and that they are twenty-five to fifty times more color-sensitive than those which Becquerel employed in his experiments. They are probably 400 or 500 times more sensitive to red than the same plates without chlorophyl.

The eosine plate shows no action in the red and orange, very little in the yellow, a great deal in the yellow-green, and considerable in the dark-green. The action of eosine is strongest exactly when the action of chlorophyl is weakest; it gives about the same degree of sensitiveness to yellow-green that chlorophyl gives to red, but in a broader band. The violet sensitiveness appears to be exactly the same as in an unstained plate.

The chlorophyl-eosine plate shows by far the most remarkable result of all. Neither sensitizer appears to have retarded the action of the other, but rather to have aided it, so that *the weakest portion of this photograph below F is stronger than the strongest portion in the blue and violet!* Nearly a year ago I recommended that chlorophyl and eosine be used together in practical isochromatic photography, and this experiment proves that the combination possesses the advantages which I claimed for it.

I have found that in order to secure the best results with the chlorophyl-eosine process, fresh, strong blue-myrtle chlorophyl solution must be used, and the amount of eosine must be strictly limited; otherwise, the plate will not be so sensitive to yellow and to blue-green. I now prefer to apply the eosine by simply tinting with it water in which the plate is to be washed after applying a plain solution of chlorophyl. I have an over-exposed negative of a bright chromo-card which I made on one of these chlorophyl-eosine plates, with an exposure of one minute in the light of a coal oil lamp, having a single small argand burner and nickel reflector. No color-screen was used, but, owing to the yellowness of the coal oil flame, all the colors have photographed correctly

An unstained plate (same collodion emulsion), with same exposure and development, showed only the high lights of the picture, very faintly.

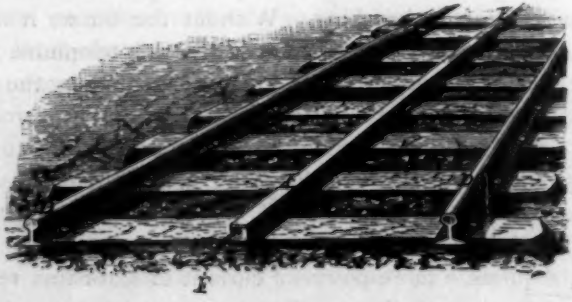
A SPRING NEAR GABÈS.—Commander Landas, who has succeeded Col. Roudaire in the region of the *Chotts*, has found a powerful subterranean sheet of water at the depth of ninety-one metres, which yields not less than 8,000 cubic metres per minute.—*Cosmos, Aug. 10, 1885.*

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE PHELPS INDUCTION TELEGRAPH.

HALL OF THE INSTITUTE,
PHILADELPHIA, October 16, 1885.

The ELECTRICAL SECTION, acting as a sub-committee of the Committee on Science and the Arts, to which was referred for examination the System of Induction Telegraphy, invented by the Mr. LUCIUS J. PHELPS, of New York, presents the following report:

A sub-committee of five members of the Section visited New York September 28th, by invitation of the Phelps Induction Telegraph Company, and inspected the operations on a line worked by this system laid on the Harlem River branch of the New York, New Haven and Hartford Railroad. The inventor, Mr. L. J. Phelps, and the Secretary of the Company, Mr. H. D. Hall, accompanied the committee. The branch has a double track from Harlem to New Rochelle, a distance of twelve miles, and the line is laid for this distance on the up-bound track. It consists of a No. 12 copper wire, insulated with okonite, laid in a groove cut in a 3 x 3-inch spruce strip, upon the top of which is tacked a one-half-inch strip as shown in the accompanying cut.



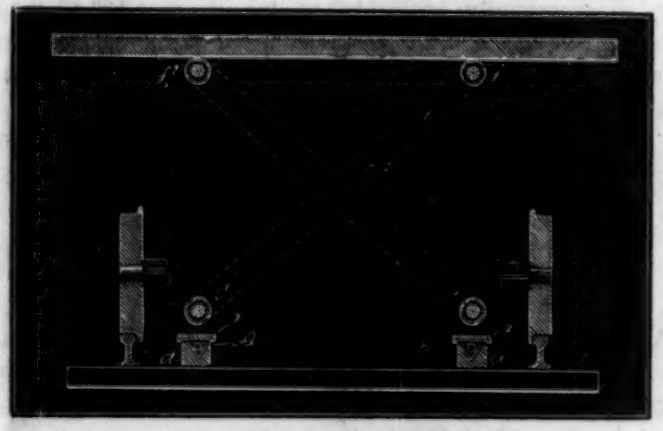
This wire is brought into the station at Harlem, where it is connected with a battery of 150 cells of a modified Bunsen type, and to the ground. It is grounded at New Rochelle, but does not enter the office at that point. A combination car on each of three trains is equipped with the apparatus. An induction coil of ninety turns of No. 14 insulated copper wire passes through a two-inch

iron tube, suspended under the car longitudinally between the trucks about seven or eight inches from the line wire. The upper portion of the coil passes through the car and is hung along the side over the windows. The instruments are set up in the baggage apartment of the car. In a cabinet under the desk is a battery of twelve Bunsen cells.

As the train left the station at Harlem, the committee left messages with the operator at that point, which were promptly sent to the parties on the train to whom they were addressed. Messages were also sent by the committee from the train to various parts of the country, which were received at Harlem and forwarded by other lines. Three members of the committee, who were expert operators, did the most of the work on the train. The messages were received on the car either by the Morse sounder or the telephone, in which could be read the Morse signals. The sender's key, however, instead of simply making and breaking the battery circuit, put in action, when depressed, a vibrator, or "buzzer," which sent alternate positive and negative currents to the line, producing a musical tone in the telephone so long as the key was held down. These rapid breaks were repeated in the induction-coil circuit in which the telephone was placed, on the well known principle that whenever the circuit of a primary battery is broken or closed a current is set up in a parallel circuit at the instant of making or breaking. Without the buzzer it would be difficult to distinguish the dots and dashes in a telephone; with it, the letters can be read with even greater ease than by the ordinary Morse sounder. When the latter is used, a relay is introduced in the coil circuit with a delicately poised polarized armature which responds only to one pole of the battery, and therefore does not reproduce the rapid breaks heard in the telephone. Its movements, therefore, correspond with the movements of the sender's key. It requires a more powerful current to work this relay than is required by the telephone. The battery carried on the car is not sufficient to operate the relay at the Harlem office, and all messages were received at that office by the telephone. This makes it necessary for the operator at that office to be constantly on the watch for business, as there is no means of calling his attention if the telephone is not at his ear. On the contrary, the operator in the car can switch in his Morse apparatus and can hear the call at a considerable distance when the train is moving.

After a stop of a few minutes at New Rochelle, the return trip to Harlem was commenced on the down-track, upon which there was no wire laid. The distance between the line laid on the up-track to the lower portion of the coil when on the down-track was 10 feet 11 inches, yet messages were received quite as well as when the coil was but eight inches from the line, although the tone in the telephone was much weaker, too weak to have any effect upon the relay of the Morse apparatus. It will be seen that the operator at Harlem could not receive messages sent from the train as readily as before, as the effect of the small battery on the car upon the line must have been quite weak; nevertheless, the messages were correctly received. It may be mentioned here that the upper portion of the coil was on the opposite side of the car from the up-track; had it been on the side nearest that track, it would have been nearly at the same distance from the line as the lower portion of the coil, and there would have been no sound in the telephone, as the currents induced in the opposite sides of the coil, being of equal strength, would have neutralized each other.

The test demonstrated the entire practicability of telegraphing between a terminal station and a moving train when but one line is used. If two lines were to be laid, it is evident that there would be an interference between the two in the induction coil on the car unless some means were devised for neutralizing one of them. The system provides for this by so hanging the coils that the two sides will be as nearly equi-distant from the circuit to be neutralized



as possible. With two coils thus arranged, both circuits could be used simultaneously on the same car. The accompanying cut shows the arrangement of the coils.

The system, however, does not seem to provide for the neutralization of the induction from one track line to the other line on the same track, which would be much stronger than the currents from the small battery on the car. For instance, it would be impracticable for the train dispatcher to receive a message from a train while a message was being sent to that train or another train on the other line wire.

If several trains were upon the road at the same time, all would be in electric communication with the train dispatcher by the same wire, but not with each other, because this would require a double induction first from the car to the line and then from the line to the second car, and the battery carried on the car is far too weak to produce any results in the other car. If, therefore, two trains should call the dispatcher's office at the same time, the dispatcher must say which one is first to use the line, as neither train would know that the other was calling.

Your committee does not consider that its duty requires consideration of the many questions of railroad management which would arise if an opinion were to be expressed about the practical application of the system to existing railroad lines. The essential feature of the invention is the utilization of induction to maintain communication between a moving train and the dispatcher's office. That is successfully accomplished by ingeniously constructed mechanism worthy of high commendation. It is for the inventor and railroad managers to find practical use for the new system.

All of which is respectfully submitted.

E. Alex. Scott, *Chairman.*
H. Fondersmith,
Addison B. Burk,
A. R. Kifer,
Alexr. E. Outerbridge, Jr.,
James Wilson.

Amended to incorporate a recommendation for the award of the John Scott Legacy Premium and Medal, and adopted as amended.

January 6, 1886. H. R. Heyl, *Chairman*

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE PROCESS AND FURNACE FOR THE REDUCTION OF REFRACTORY ORES, AND THE PRODUCTION OF METALS, ALLOYS AND COMPOUNDS, INVENTED BY EUGENE H., AND ALFRED H. COWLES.

The CHEMICAL SECTION, acting as a sub-committee of the Committee on Science and the Arts, to which was referred for examination the COWLES process and furnace for the reduction of refractory ores and the production of metals, alloys and compounds; and further, upon the character of the specimens of aluminium bronze, aluminium brass, aluminium silver, silicon bronze, and so forth, as submitted by the company, presents the following report:

There were offered for examination specimens of aluminium ores, aluminium bronze, aluminium silver, aluminium brass, and silicon bronze in ingots, castings, wire and rolled metal, some screws of aluminium brass, knives with blades of aluminium silver and handles of aluminium bronze, and a few other manufactured articles, as well as an ingot of aluminium containing about nine per cent. of silicon. The committee listened to the paper presented to the INSTITUTE at its last meeting by Mr. COWLES, and has, since then, made as thorough an examination of the process as was possible in the absence of an opportunity to see the furnace in operation.

Of the patents secured by the Messrs. COWLES, the specifications of the most important three are appended to this report, and cover: "A Process of Smelting Ores by the Electric Current," "An Electric Smelting Furnace," and "An Electric Process of Smelting Ores for the Production of Alloys, Bronzes and Metallic Compounds."

The essential and valuable novelty of the process is the ingenious application of the intense heat obtained by the passage of a powerful current of electricity through a conductor of great resistance, to the reduction, in the presence of carbon, of the most refractory ores, some of which have hitherto resisted all similar attempts at reduction. In this process, the crushed ores mixed

with fine charcoal, and, for the production of alloys, with fragments of copper or some other metal or metals, form the part of the circuit offering the greatest resistance to the electric current, and subjected, therefore, to the highest temperature. The heat developed is so great that nearly all oxides are decomposed, and charcoal is changed to graphite.

The reduction is effected in an oblong, rectangular box, whose interior dimensions are the following : length, 5 feet ; width, 1 foot ; depth, 1 foot. The walls and bottom are constructed of fire-brick, while the top is a cast iron slab. The charge, consisting of copper or some other metal, fine charcoal and the ore to be reduced, occupies, in the central part of the furnace, a space 3 feet in length, 9 inches in width, and 3 inches in depth. Beneath the charge, separating it from the bottom of the furnace and on all sides of it, is a packing of limed charcoal, which prevents loss of heat by conduction or radiation, and protects the fire-brick from disintegration.

Immediately beneath the charge is a layer of pure charcoal, to prevent the introduction of calcium from the limed charcoal into the alloy.

Through each end of the furnace projects a large electric light carbon, called an electrode, extending through the limed charcoal into the charge. More charcoal is added, filling completely the box, the cover is luted on, and a current of 1,200–1,500 ampères, furnished by a dynamo-electric machine, is passed for five hours through the furnace, which is practically air tight, although two or three openings are made through the top to permit the escape of the gases generated during the reduction.

The process is placed under the control of an operator of only ordinary intelligence, with the aid of the ampèremeter, resistance box and electrodes. At the beginning of the "heat," the latter penetrate the charge, and the current passes through only a small portion of the mixture, but they are gradually drawn apart until the entire charge lies within the zone of fusion.

To obtain the product of the reduction it is necessary, at present, to allow the furnace to cool, but the company hopes to make the process continuous. It will then be possible to introduce fresh portions of the charge through openings in the top of the furnace, while the molten alloy may be drawn from the lower part. When ores yielding volatile products are employed, the furnace differs slightly from the one described.

The charge for the production of aluminium bronze consists of fifty pounds of granulated copper, twenty-five pounds of crushed aluminium oxide (corundum) and twelve pounds of a mixture of charcoal and electric light carbon. When the furnace is cleaned, there are found in the lower part about fifty pounds of a copper alloy containing fifteen to thirty-five per cent. of aluminium and a small quantity of silicon. From this alloy, standard aluminium bronze alloys may be prepared by remelting it with the proper amounts of copper. Higher in the furnace is obtained a grayish fused mass, composed of carbon and aluminium, that may prove to be a carbide of aluminium. The latter element is present in quantities varying from thirty to sixty per cent.

The chemistry of the process, so far as it is understood, is simple. The carbon, aided by the high temperature, removes the oxygen from the corundum with the formation of gaseous carbon monoxide. A small amount of aluminium is obtained in grains mixed with charcoal, another portion unites with copper to form the alloy, while the remainder combines with carbon and yields a crystalline compound.

It is possible that electrolysis plays some part in the decomposition, but no proof has yet been given that it does. If copper alone be heated with the aluminium oxide, the reduction does not occur. When corundum is heated with charcoal alone, the aluminium unites with the carbon, yielding the crystalline compound referred to above. The former length of the heat was about one hour, the increase to five hours enlarges the yield of the copper alloy, with a comparative decrease in the yield of the carbon compound.

This process is applicable to the reduction of all kinds of ores, but particularly to those unreducible by other means.

The value of the aluminium bronzes and other alloys containing aluminium is so well known, that we shall say only a few words concerning them. Full and interesting details may be found in metallurgical works, chemical dictionaries, engineering and special text books, as well as in the pamphlet published by the Cowles Electric Smelting and Aluminium Company.

All authorities unite in their praise and predict an extensive use for them. Their high price alone has prevented their general employment, but in spite of their costliness the demand is not inconsiderable. The usefulness of the aluminium bronzes is due to

great hardness, tensile strength and stiffness. They are also ductile, malleable at high temperatures and elastic. They resist the action of the air, moisture and many other chemical agents far better than brass or bronze. The lustre of silver or gold may be given to them. Under some conditions, these metals tarnish more readily than the aluminium bronzes. They may be cast, rolled or forged. The castings are of great strength and homogeneous; repeated melting decreases their tensile strength but slightly without causing any loss of weight. Large castings may be made with care; almost perfect small castings are readily secured. The Messrs. COWLES claim that heavy guns could be cast from aluminium bronze, which would be stronger than guns of forged iron or steel, more enduring and cheaper. A well-known authority calls aluminium bronze "the best bronze yet known."

Aluminium silver, an alloy containing aluminium bronze and nickel is valuable for cutlery. The tensile strength, lightness, non-corrosiveness and electric conductivity of silicon bronze renders it a most desirable substitute for iron and copper in telegraphy and telephony. Aluminium brass far excels ordinary brass in hardness, strength and durability. It is also cheaper. Admitting the great worth of these alloys, let us consider for a moment the important question of their cost.

The works at Cleveland, which are in reality only an experimental plant, produce daily about 400 pounds of aluminium bronze, selling at fifty or sixty cents per pound. The Lockport works will have a capacity of 3,000 pounds per day, and the company expects to sell the bronze for less than forty cents per pound; in fact, Mr. COWLES intimates in his paper that the price may be as low as fifteen cents per pound.

At the present price of aluminium bronze, the aluminium that it contains, costs about $3.80 per pound. Should the alloy be sold for fifteen cents per pound, the aluminium will be sold for about forty cents per pound. The price of aluminium manufactured by other processes is not under $9 per pound. The Cowles Electric Smelting and Aluminium Company promises to furnish within a year pure aluminium for fifty or sixty cents per pound. If raw material of sufficient purity can be obtained cheaply, this can probably be done. Possibly the so-called carbide of aluminium may be employed. It has been already utilized in the manufacture of

an extremely pure chloride of aluminium. In the absence of sufficient information regarding the process for the production of pure aluminium, the committee is unable to discuss the question intelligently. On the other hand, from an examination of an itemized statement, furnished by Mr. COWLES, showing the running expenses for several weeks of the works in Cleveland, and in consideration of the simplicity of the process, the cheapness of the raw material, and freedom from the use of expensive chemicals, the committee believes that the production of alloys and metallic compounds, cheaply and on an industrial scale, is assured. The members of the committee have, moreover, no doubt of the ultimate success of the company in its endeavor to produce pure aluminium at a moderate cost. The scientific possibilities of the inventions must not be overlooked. The intense heat of the electric current is so completely under the control of the investigator, and the other conditions are so favorable, that not the slightest doubt should exist of speedy and valuable additions to our knowledge of metallurgical and chemical processes. Already aluminium alloys of iron, silver, tin, cobalt and nickel have been prepared; silicon, boron, potassium, sodium, magnesium, calcium, chromium and titanium as well as aluminium have been obtained in a free state. An apparently new oxide of silicon awaits study. The opportunities for the formation of new and important alloys seem unlimited, and it is not improbable that some of our elements may be resolved into different kinds of matter.

Much speculation is, however, out of place in a report of this kind; but the committee is of opinion, that the Messrs. COWLES and their associates deserve the highest commendation for their inventions, furnishing, as they do, a distinctly new and important metallurgical process, that will render possible the cheap production of useful alloys, compounds and metals, and giving to science a valuable aid in research.

LYMAN B. HALL, *Chairman.*
HENRY PEMBERTON, JR.,
HENRY TRIMBLE.

Amended to incorporate a recommendation for the award of the John Scott Legacy Premium and Medal to the inventors for their electric smelting furnace; and of the Elliot Cresson Medal, for their

invention of a new process in the metallurgical arts for the reduction of refractory substances; and, as so amended, adopted.

H. R. HEYL, *Chairman.*

Philadelphia, Wednesday, April 7, 1886.

SOME ADDITIONAL FACTS CONCERNING THE REIS ARTICULATING TELEPHONE.

BY PROF. EDWIN J. HOUSTON.

[*Read at the Stated Meeting of the* INSTITUTE, *June 16, 1886.*]

Whatever the decisions of the United States Circuit Courts have been in the past, or whatever they may be in the future, there can be no reasonable doubt, that in the opinion of the general scientific world, to Reis and not Bell will be accorded the credit of having made the great discovery of the methods and apparatus for the electrical transmission of articulate speech.

We have elsewhere maintained the following propositions, viz.:

1st. Reis invented an instrument which he called a telephone, and which he said would transmit speech

2nd. That this telephone operated by means of electricity, and consisted of transmitting and receiving apparatus.

3rd. That in the hands of Reis it did transmit intelligible, articulate speech; and that credible witnesses are still alive who heard it so transmit speech.

4th. That exact reproductions of the Reis apparatus, operated in accordance with his directions, will transmit speech now.

To the above it is answered, despite the published statements of Reis to the contrary,

1st. That Reis devised his apparatus to transmit musical tones, and not to transmit articulate speech.

2nd. That there is but one method by which articulate speech can be transmitted electrically, viz., by an undulatory current, and therefore Reis never could have transmitted articulate speech telephonically, since, it is alleged, he did not use the undulatory current. Any, consequently, who imagined that they heard articulate speech through the Reis apparatus must have been deceived.

3rd. That if reproductions of the original Reis apparatus have

been made to transmit articulate speech, however, exact they may appear, they must have been varied in some important (although inappreciable) respect.

The transparent sophistries of the above answers are, in our judgment completely swept away by the experiments of Mr. John R. Paddock, of the Stevens Institute of Technology, which although of an early date we have but recently received and had permission to publish. These instruments have been introduced into the Overland Telephone Cases, on appeal to the Supreme Court.

Mr. Paddock's experiments appear to clearly establish, what at the outset should have been apparent to any fair inquirer; viz., that *the original Reis apparatus, without any change whatever, will transmit intelligible, articulate speech.*

The apparatus used by Mr. Paddock, were the identical apparatus employed by Reis in his lecture before the Physical Society at Frankfort a-M., in 1861–2. They were obtained by Hon. A. J. Keasbey, from Prof. S. P. Thompson of Bristol, England, who got them from Dr. Theodore Stein, of Frankfort, Germany. Dr. Stein got them from Prof. Dr. Böttger, President of the Physical Society of Frankfort, who received them direct from Reis, after the above mentioned lecture. The story as above told is fully substantiated by testimony taken at Frankfort a-M.

The following letter from Mr. Paddock, will, however, give the particulars at length.

STEVENS INSTITUTE OF TECHNOLOGY,
HOBOKEN, N. J., Feb. 12, 1886.

PROFESSOR E. J. HOUSTON, FRANKLIN INSTITUTE, Phila.

I have read with much interest your articles in the London *Electrical Review* relating to the Telephone and the invention of Philip Reis.

Having facts concerning the same which have not yet been made public and which are of especial interest at this time I take the liberty of placing them at your disposal. In the summer of 1885 I came into the possession of the *Original Bored Block Transmitter* and *Knitting Needle Receiver*, exhibited by *Philip Reis* before the Physical Society, at Frankfort-a-M. in 1861–2. These instruments were obtained by Hon. A. Q. Keasbey, Counsel for the Overland Telephone Companies, from Professor Thompson of Bristol, England, who received them from Dr. Theodore Stein, of Frankfort, Germany, and he in turn from Prof. Dr. Böttger, President of the Physical Society at Frankfort, to whom *Reis himself* gave these instruments after the lecture above referred to. Their history is thus fully proved and their identity has been further established by testimony taken at Frankfort a-M.

The instruments were in a good state of preservation when received by me and required no alterations or additions whatever with the exception of a wooden support for the needle of the receiver which was wanting, and a slight mending of the wooden case which had become broken, evidently during transportation.

With these instruments I soon succeeded in transmitting and receiving good articulate speech. Musical sounds and songs were easily reproduced and it is important to remark that when the transmitter was so operating as to transmit musical sounds *best* it was also so operating as to transmit articulate speech *best*, which in view of the oft repeated statement that the Reis instruments are capable of transmitting *the one*, but incapable of transmitting *the other*, is of especial value as showing that the same condition of the transmitter is required for both. The *pitch* of a musical sound was *not* the only results achieved by Philip Reis with his instruments but also *amplitude* and to a good degree *quality* also, as is proved by the publications of his day (see Annual Report of the Physical Society of Frankfort-a-M. 1861–2. Also, the Deutsche Industrie-Zeitung for 1863)

Mr E. W. Smith, a practical Telephone Operator, assisted me in this work and together we were able to transmit and receive many words and sentences in as *clear* and *distinct* a manner as in any *modern telephone*, and this notwithstanding that the instruments we were using were now nearly twenty-four years old and that the diaphragm of the transmitter was made of a thin animal membrane which soon absorbs the moisture of the breath and then of course loses its tension and fails to respond to the vibrations of the voice.

In describing the operation of this very instrument, Philip Reis in his lecture before the Physical Society at Frankfort makes the following statement:

"If, now, sounds or sound combinations are produced in the neighborhood of the block, so that sufficiently powerful waves reach the opening *a*, then these sounds cause the membrane *b*, to vibrate. At the *first condensation* the *hammer-like wire d, is pushed back*, at the *rarefaction* it *cannot follow the retreating membrane, and the current* traversing the strip *is broken*, until the membrane forced by a new condensation again presses the strip (proceeding from *p*,) against *d*. In this way *each sound wave causes a breaking and closing of the circuit.*" (The italics are Mr. Paddock's.)

This is the description chiefly relied upon to prove that the Reis instrument operates by means of a *broken current* and hence is incapable of transmitting speech, for it is maintained a current *broken* at each vibration *can not* transmit speech, and Reis distinctly says himself that the current *is* thus broken, therefore, &c.

We have endeavored experimentally to test this most *vital point* so far as regards Reis and his instrument. Whether there are minute breaks in the current during the ordinary use of a Microphone transmitter is a matter still in doubt and one which only indirectly bears upon this question.

The real question is— Did Philip Reis so operate his Telephone as to break the current (as he supposed he did) and if so did he obtain speech in that way—(as he says he did)

We have operated the Reis instruments in *exact conformity* to his description and to *this* very paragraph of that description. When thus operated

"The hammer-like wire *is* pushed back but *can not* follow the retreating membrane and parts from it." A continual humming is kept up as the two platinum contacts strike one-another and a succession of sparks indicate the parting of the electric current at each vibration.

While *so* operating in exact accordance with the description of Reis himself the following sentence has been distinctly transmitted and received

"*William H. Vanderbilt died suddenly at his house on Fifth Avenue, yesterday. He is said to have been worth two hundred million of dollars,*" a sentence of twenty-three words which of itself is clear proof that articulate speech can be transmitted in the Reis instrument when used with the *so called broken current.* We are at present engaged in ascertaining the extent to which this old instrument will transmit speech under these conditions and the work thus far done points to the conclusion that it is far greater than has hitherto been supposed. Photographic records will also be obtained of the vibrations produced under these circumstances which will form an interesting subject for study—and lead to more positive conclusions.

With reproduced forms of a later Reis instrument viz The cubical box form, we have transmitted speech at greater length—one sentence consisting of fifty-six consecutive words. A full statement of these experiments appears in the record of The Overland Telephone Cases, now on appeal to the Supreme Court. With esteem and regards,

Very Truly Yours

JOHN R. PADDOCK,

Instructor in Physics and Chemistry.

The importance of the above statements, substantiated as we do not doubt they will be, can hardly be overestimated. If established, they sweep away completely the broad claims that the Bell Telephone Company have been so pertinaciously endeavoring to establish for Bell. They completely dispel the legal mists, that have so skillfully been maintained around the early labors of Philip Reis, and hasten the time, when the general public, will be ready to do what the general scientific public, the world over, has already done, viz, accord to Philip Reis the credit due to his wonderful discovery.

The importance of Mr. Paddock's experiments will, perhaps, be the better understood by examining some of the recent decisions in the Circuit Courts on the legal value of the Reis apparatus as anticipations of the articulating telephone of Bell.

In the recent New Orleans Telephone decision, in the case of the American Bell Telephone Company, *et al,* vs. the National Improved Telephone Company, *et al,* Judges Pardee and Billings in their decision, spoke as follows:

"From the evidence submitted in the case it seems clear that now, in the present state of the art, neither that Reis' instruments

nor any reproduction of them can be made to transmit articulate speech except by changes of some form in the instruments or by the employment of Bell's method."

"We, therefore, conclude that neither Reis nor his successors anticipated the invention of Bell as set forth in the fifth claim of his application and patent, and as illustrated by Fig. 7, described in his accompanying specification."

But if the original apparatus, without any change will speak, what then?

In the American Bell Telephone Company vs. Amos E. Dolbear, et al, Judge Lowell on Aug. 25, 1883, in giving the opinion of the court in this case said "The defendant now testifies that the Reis instrument can be made to transmit speech, under some circumstances, if operated in the way which Bell has shown to be necessary." * * * * * "The experiment made in the presence of counsel, which was intended to prove the correctness of the defendant's present opinion, was an utter failure. But if it be admitted that the Reis instrument is capable of such use, to a very limited extent, and after a change in its proportions, and when used in a way which the inventor did not intend, still, I am of opinion that it was not an anticipation of Bell."

But if the original apparatus without a change in its proportions, and when used in a way which the inventor intended will transmit speech, what then?

Alluding to the success in making the apparatus described in Fig. 7 of Bell's original specification talk, Judge Lowell says:

"This great result has been reached by Mr. Bell entirely through the improvements described in his second patent (1877 patent) such as the substitution of a metal plate for a stretched membrane, and some others" and these early unsuccessful efforts he says are "now immaterial, for it is proved that the instrument will do the work, whether the inventor knew it or not, and in the mode pointed out."

But if it be now proved that the original apparatus will do the work, which its inventor claimed it would do, (not which he hoped it would do, or was ignorant it would do), what then?

In a case that has been so full of surprises, as the telephone litigations, we must confess to considerable curiosity as to what the courts and the legal advocates of Bell will do with the above evidence.

The author has not personally tried the experiments referred to, but hopes to do so on the first opportunity. Mr. Paddock promises to give him additional information at an early day.

CENTRAL HIGH SCHOOL,
Philadelphia, June 16, 1886.

BOOK NOTICES.

THE PRESERVATION OF TIMBER BY THE USE OF ANTISEPTICS. Samuel Bagster Boulton, Assoc. Inst. C. E. Van Nostrand's Science Series. No. 82. Price, 50 cents, post free.

This little volume comprises an interesting essay on the above subject, read before the Institution of Civil Engineers, and a report of the discussion which followed, in which many prominent members, including the eminent chemists, Dr. Tidy, Dr. Voelcher, and Dr. Armstrong, took part.

The process termed "Creasoting," is the main topic, and the principal question under discussion is, which portion of the "Creasote oils" is the more valuable preservative agent, the lighter portions, containing the carbolic and cresylic acid, or the heavier portion, containing the bulk of the naphthaline?

In England, the use of coal tar creasote has superseded all other methods of wood preservation, and of latter years there has been a strong tendency to increase the proportion of the lighter constituents. The author of the essay contends that this is a retrograde practice, and that the permanence of the preservation by the creasote is thereby diminished.

A wood preservative, to be permanently effective, must be insoluble in water, so as not to be liable to be washed out in damp situations, and to a great extent, non-volatile, especially when the timber is exposed to the summer sun. Carbolic and cresylic acids are soluble and volatile, and therefore may, in a short time, be completely removed from creasoted timbers which have been placed in exposed situations. This is found to be a fact on examination of creasoted timbers in service for about one year, scarcely a trace of carbolic acid being found in them, although the timbers were still in a perfectly sound condition. The more solid substances, as naphthaline, remained in the wood, and further investigation seemed to show that this was the chief preservative agent. In the opinion of the author, with which several speakers coincided, the main object of "creasoting" was to choke up the pores of the wood thoroughly with a permanent solid substance, so that neither air, water nor organic life could penetrate it, and that this substance must also possess antiseptic properties in order to destroy the vitality of germs or organic growth already contained in those pores. It will not do to coat the outside merely with an impervious material, for the moisture and decay producing agents within are thereby retained, especially in green timber, and by this means decay goes on more rapidly than when no preservative has been applied. The crude naphthaline seems admirably fitted for this choking process, being insoluble, only slightly volatile at ordinary temperatures, has antiseptic properties of its own, and has associated with it other bodies, which are also antiseptics. It is necessary that the creasote

should contain some of the lighter oils only for the purpose of rendering the whole capable of thoroughly permeating the timber at the proper temperature. That carbolic acid produces any permanent preservative effect by coagulation of the albuminous constituents of the wood is doubtful, although some believe that this coagulation does take place. Dr. Armstrong, however. "doubts that this takes place to any great extent, or is an essential part of the process."

With the reduction of the proportion of lighter oils, the author recommends a higher temperature for the injection. The usual method is to put the timber in a closed tank exhaust by the air pump run in the creasote heated to a temperature of 100° to 120° F., and then force the liquid into the wood by means of a pressure pump. Mr. Boulton heats the creasote to somewhat over 212° F., and continues the use of the exhaust pump after the introduction of the fluid into the tank. He claims that by this modification the whole of the moisture is perfectly removed even from very wet timber. Much time is therefore saved over the old process when damp timber had to be stacked for several months before being creasoted In regard to the preservation of young wood and sap wood, Mr. Boulton stated that the same creasotes were by his method "always used for both these and old wood and with complete success. It had been clearly established that the heavy oils preserved sap wood from decay." He also added "that the attempt should never be made to inject creasote or any other oily substance without previously or at the time of the operation expelling watery moisture, and that the timber should not be felled while the sap was in it." If an open tank was used for the creasoting more care was required than with the closed tank to obtain good results, and wet timber could not be treated at all, without raising the temperature so high as to cause brittleness. Under no circumstances should the temperature be allowed to rise above 250° F., otherwise the fibre of the timber tends to become permanently injured and weakened.

Mr. Boulton gives a number of striking instances of the durability of creasoted timber. In 1882, he examined eleven specimens of old creasoted sleepers from the permanent way of the London and Northwestern Railway, which had been in use for periods ranging from sixteen to thirty-two years. Also sleepers from the Taff Vale Railway, the Southeastern Railway and the Great Eastern Railway, which had been in use from fourteen to twenty-three years. A portion of the Victoria Dock fence was found to be perfectly sound after twenty-nine years use. All of the above examples were of ordinary Baltic fir. They were all tested for presence of carbolic acid and no tar acid could be found, and it was clearly established that they had been preserved by the heaviest and most solid portion of the tar oils.

At the time of the Paris Exhibition, of 1878, beechwood sleepers creasoted by Mr. Boulton's firm in England, in 1859, which had been in service on the railway from Rouen to Dieppe for twenty years, were examined and not one of them was found to show the slightest trace of decay. This statement was made by Mr. A. Bouisson, of the Western Railways of France. He also states that the company for which he was engineer, had since 1864 applied the creasoting process to about 5,000,000 sleepers, of which at least 3,500,000 were beechwood. In these latter as in the case of the Rouen and Dieppe

line no signs of decay had as yet been discovered, although uncreasoted beechwood was of very perishable nature.

In view of the rapid and alarming destruction of our own Eastern forests and those of Canada and also in view of the fact that the stock of hard woods in our Southern and Western States has already been largely drawn upon, it would be well for American engineers to consider the advisability of the adoption of the creasoting process in this country. R. H.

THE WORK OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS AND OF ITS COMMITTEES. Published by the American Committee, under the direction of Dr. Persifor Frazer.

Among the sciences, geology is one of the most likely to provoke the proverbial disagreement of the doctors. The expansion of the rocks of a certain horizon at one point, their contraction, or extinction, at another, making that which is in Britain a prominent feature, on the continent an insignificant one, besides the many other causes of difference of opinion, makes an agreement among the geologists of different countries difficult, and possible only by the influence of a feeling among them, that many personal opinions must be held in abeyance in order that the desirable end may be accomplished, an end which all agree would much advance the science.

It is therefore with great pleasure that the scientific world will peruse this pamphlet. In all the discussions the end was kept prominently in view, the salient points on which all, or nearly all, were agreed were fixed and the doubtful ones seem to have been so treated as to conflict seriously with no opinion. Difficult as was this task, it was to an admirable degree accomplished.

The color scale proposed seems well adapted to its purpose, and the proposition to add a significant letter as well as the color will conduce greatly to the clearness of the map, especially, when by age the colors have somewhat changed.

The decisions of the Congress as to the colors were as follows:

"The Carbonic system (or Permo-carboniferous) will be represented by a gray color in three tints."

The color of the Siluric system was left to the choice of the Committee on the Map.

The eruptive rocks will be represented by seven tints, from bright red to dark brownish-red.

Archæan was chosen as the name for the Pre-Cambrian group, and the word group in preference to system.

The division of the Archæan was left to each geologist; the question of sub-dividing the Cambrian and Silurian was deferred.

The determination of other questions arising on the report of the Committee on the Map was left to that committee.

The report of the Committee on the Map is exhaustive and able. Justice cannot be done to it in a brief abstract. Thirty-two sheets of the topographic base for the map are furnished and engraved, leaving but seventeen to be done; but the geological work is much less advanced.

The report of the commission for the uniformity of nomenclature contains many valuable suggestions, and if generally adopted and used will add much to the clearness of geological reports.

Abstracts are given of the reports of the German, the English, the Belgian, the Spanish, the French, the Hungarian, the Portugese, the Roumanian and the Swiss Committees, also a communication from Prof. Renevier upon the monograms decided upon by the commission on the maps to indicate the series of rocks.

T. D. R.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, June 16, 1886.*]

HALL OF THE INSTITUTE, June 16, 1886.

COL. CHAS. H. BANES, President, in the Chair.

Present—160 members and eleven visitors.

The election of seven persons to membership was reported.

The Secretary, for Mr. JOSHUA PUSEY, read a paper descriptive of a new System of Weather Signalling.

Prof. EDWIN J. HOUSTON presented some additional facts respecting the invention of the Articulating Telephone.

Mr. FRED E. IVES presented a further communication on his researches in Isochromatic Photography.

The above have been referred for publication.

The Secretary read a communication from Mr. J. E. WATKINS, stating the fact that a Section of Steam Transportation (Railways and Steamboats) had been established in the U. S. National Museum, and requesting the coöperation of the INSTITUTE, in suitably setting forth the value of the work which such a section might accomplish, in collecting together and preserving from loss many objects of great historical interest. The communication was accompanied by several documents, describing the details of the plans it is proposed to follow; whereupon the following preamble and resolution were unanimously adopted, viz.:

"WHEREAS, a petition signed by over eleven hundred (1,100) prominent railway officials of the United States, has been presented in the House of Representatives, by the Hon. J. B. Everhart, and referred to the Committee on Appropriations, which petition reads as follows: 'To the Congress of the United States: The undersigned, desirous of perpetuating the history of the birth and development of Steam Transportation (by Steamboat and Railway) in America, respectfully petition your honorable body to appropriate such a sum of money as may be deemed necessary to carry out the plans recently adopted for the organization of the section of steam transportation in the U. S. National Museum; said sum to be expended under the supervision of Prof. Spencer F. Baird, Secretary of the Smithsonian Institution, and Director of the U. S. National Museum;' therefore,

"*Resolved*, That the FRANKLIN INSTITUTE of the State of Pennsylvania, for the Promotion of the Mechanic Arts, most heartily and cordially concurs in the purpose and objects of this petition, and respectfully requests favorable action thereon."

The Secretary's report embraced remarks on the report of the Engineer Commission on the Panama Canal; on further advances in the production of cheap Aluminium; on Natural Gas, its occurrence and applications; the tunnel under the Harlem River for the new Croton Aqueduct; on Glen & Melville's new proposal in Multiplex Telegraphy; and on the important bearing of the recent judicial decision in England affirming the validity of the Cheesbrough (Sawyer-Mann) patent.

Wm. A. Bigler's Electric Circuit-Making and -Breaking Device, Henry Gut's Ratchet Reamer and Countersink, and Müller's Sectional File were described and exhibited.

The meeting then proceeded to take action upon a number of proposed amendments to the By-Laws, and was thereupon adjourned.

WM. H. WAHL, *Secretary.*

RETRIBUTION BY ELECTRICITY.—During a religious *fête* at Cotopaxi a band of robbers attempted to extinguish the electric lights of the cathedral in order to profit by the confusion and obscurity. The chief put his hands upon the wires with the intention of cutting them, and in doing so he established a current through his body which put him to death.—*Cosmos, Aug. 10, 1885.*

SWISS GLACIERS.—The diminution and retreat of the Swiss glaciers seem to have ceased, and in some instances there has been a marked advance. In the Valley of Chamouni the Argentière has gained ten metres during the past year, and the Boisson has gained forty-five metres. The advance is much more strongly marked in the Western glaciers than in the Eastern.—*Cosmos, Aug. 10, 1885.*

REACTIONS UNDER THE INFLUENCE OF PRESSURE.—When a mixture of carbonate of sodium and sulphate of barium is melted, there is a complete reaction when the sodium carbonate is employed in sufficient quantities. After cooling, the soluble salts can be removed by the aid of water, and the insoluble residue is formed exclusively of carbonate of barium. W. Spring has found a similar reaction, though less complete, from the influence of pressure alone, which is a fact of some consequence in the study of the molecular actions, which take place between solid bodies in contact. He has experimented under pressures of about 6,000 atmospheres, continuing for intervals varying between a few seconds and twenty-four days, and also upon the combined influences of pressure and temperature. In the latter case he has found, as might have been anticipated, that heat exercises an influence opposed to that of compression. These experiments have an obvious bearing upon the diffusibility of matter in a solid state, as well as upon the explanation of some other natural phenomena which are not yet well understood.—*Bul. de l'Acad. de Belg. No. 8, 1885.*

LIST OF BOOKS.

ADDED TO THE LIBRARY FROM MARCH 1, 1885.

Kansas State Agricultural College. Fourth Biennial Report. 1883–84.
Kansas State Board of Agriculture. Report for April, 1884.
Presented by Lewis S. Ware.

Kendo, T. A. Treatise on Silk and Tea Culture. San Francisco, 1870.

Kentucky State Sanitary Council. Proceedings, Addresses and Discussions of the Third Semi-Annual Meeting, held at Bardstown, March 22–27, 1884, and Proceedings of the State Board of Health, held March 16–17, 1885. Presented by the Board.

Labor in Europe. Letter from the Secretary of State. Washington, 1885.
Presented by the Department of State.

Lake Shore and Michigan Southern R. W. Co. Cleveland, Ohio. Fourteenth and Fifteenth Annual Reports to the Stockholders. 1883–84.
Presented by the Company.

Lamps, Electric and Carbons for Arc Lamps. Report of Examiners of Sections 5, 6, and 8, International Electric Exhibition. 1884. FRANKLIN INSTITUTE, Philadelphia.

Land Office, U. S. Annual Reports of the Commissioner for 1883–84. Washington. Presented by the Commissioner.

Laudrin, Jr., M. H. C. Treatise on Steel. Translated from the French by A. A. Fesquet. Philadelphia, 1868.

Laureau, L. G. Bessemer Converting House without a Casting-Pit. Transactions American Institute Mining Engineers. 1885.

Leloutre, G. Vérification d'une Série d'Essais sur une Machine de Woolf, Paris. Bernard Tignol. 1885. Presented by the Author.

Le Van, W. B. Economy in the use of High Pressure Steam. Reprinted from JOURNAL FRANKLIN INSTITUTE. May, 1885.

Le Van, W. B. Modern Railroad Facilities.

Le Van, W. B. Transportation Facilities of the Past and Present. Read at FRANKLIN INSTITUTE. May 20, 1885.

Lilienberg, N. A Water Gas Open-Hearth Furnace. Transactions American Institute Mining Engineers. 1885. Presented by the Institute.

Lincrusta-Walton. A new Decorative Material. Its Artistic, Sanitary and Commercial Value. Presented by J. C. Finn & Son.

Liverpool Engineering Society. Annual Report for 1884.
Presented by the Society.

Locomotive, The. Vol. 5. New Series. Hartford, 1884.
Presented by Hartford Steam Boiler Inspection and Insurance Company.

London, Edinburgh and Dublin Philosophical Magazine. Series 5, Vol. 17 and 18. London, 1884.

Long, John C. New Regenerative Hot-Blast Oven. Transactions of American Institute of Mining Engineers. 1885. Presented by the Institute.

Louisiana Board of Health. Annual Reports for 1874, 1880 and 1882-83. New Orleans and Baton Rouge, 1875-83.

Louisiana Board of Health. Annual Reports for 1873, 1875, 1877-79.
Contagious and Infectious Diseases. 1884.
Quarantine and Commerce. 1884.
Sanitary Conference. 1884.
Commercial Bodies of New Orleans. Report of Joint Committee of 1884.
Presented by the Board.

Louisiana. Weekly Statements of the Board of Health. March 7 to April 18, 1885.
Sanitary Condition of the Island of Jamaica. By L. F. Salomon.
Presented by the Board.

Lubbock, Sir John. Pre-Historic Times. New York: D. Appleton & Co., 1872.

Ludlow, Col. Wm. Water Supply in Relation to Sanitation. An Address to the County Medical Society of Philadelphia. Delivered March 30, 1885.
Presented by the Author.

Lynn. Public Water Board. Twelfth and Thirteenth Annual Reports for Year 1883 and 1884. Lynn, Mass., 1884. Presented by the Board.

Lumière Electrique. Vols. 11-14. Paris, 1884.

Lumber Depot, The Great. Circulars, Nos. 1-15. Presented by A. J. Geiger.

Machinery and Mechanical Appliances. Report of Examiners of Section 30, International Electrical Exhibition.

Magnetical and Meteorological Observations. Bombay, 1879-83. By Chas. Chambers. Bombay, 1883. Presented by the Government.

Magnetical Observations. Abstracts made at Toronto, Canada. 1856-62.
Presented by the Observatory.

Magnetism of Iron and Steel Ships. By T. A. Lyons. Naval Professional Papers. No. 17. Washington, 1884.
Presented by the Bureau of Navigation.

Maine. Board of Agriculture. Fifth, Eighth, Ninth, Eleventh to Thirteenth Annual Reports of the Secretary. 1860, 1863, 1864, 1866-1868. Augusta.

Maine. Board of Agriculture. Annual Reports of the Secretary for 1883. Augusta, 1884. Presented by the Board.

Manchester. Association of Employers, Foremen and Draughtsmen of Mechanical Trades of Great Britain. Reports of Proceedings and Papers Read. Presented by the Association.

Manchester Steam Users' Association. Annual Report of the Committee of Management for 1884. Chief Engineer's Monthly Reports for January to November, 1883. Presented by the Association.

Manual of the Railroads of the United States for 1884. By H. V. and H. W. Poor. New York, 1884.

Marsh, G. P. The Earth as Modified by Human Action. New York, 1874.

Massachusetts. Annual Report of the Insurance Commissioner for 1884, made January 1, 1885. Boston. Presented by the Commissioner.

Massachusetts. Annual Reports Relating to the Registry and Return of Births, Marriages and Deaths for 1863–1869, 1871–1873, 1875, 1878, 1880–1883. Presented by the Hon. Secretary of State.

Massachusetts. Catalogue and First Supplement of the State Library. Boston, 1880–81. Presented by the Secretary of State.

Massachusetts. Census of 1875. A Compendium. Prepared by C. D. Wright. Boston, 1877. Presented by C. D. Wright.

Massachusetts. Census of 1880. Compiled by Authority of the Legislature. By Carroll D. Wright. Boston, 1883. Presented by C. D. Wright.

Massachusetts Agricultural College. Twenty-second Annual Report and Catalogue. January, 1885. Boston. Presented by the College.

Massachusetts Charitable Mechanic Association. Report on Fifteenth Exhibition. Boston, 1884. Presented by the Association.

Massachusetts State Agricultural Experiment Station. Bulletin No. 14 and 15. 1885. Presented by the Station.

Massachusetts State Board of Education. Forty-fourth, Forty-fifth, Forty-seventh and Forty-eighth Annual Reports. 1879–84. Boston, 1881–85. Presented by the Board.

Massachusetts State Board of Health. Lunacy and Charity. Third Annual Report for 1881. Boston, 1882. Presented by the Board.

Massachusetts State Board of Health. Ninth and Tenth Annual Reports. Boston, 1878–79.

Massachusetts State Library. Report of Librarian. 1884. Boston. Presented by the Librarian.

McDermott, W. Combined Amalgamation and Concentration of Silver Ores. 1885. Presented by American Institute of Mining Engineers.

Medical Directory of Philadelphia, Pennsylvania, Delaware and the Southern half of New Jersey. 1885. Philadelphia: P. Blakiston, Son & Co. 1885. Purchased with the Legacy of B. H. Moore.

Medical Society of the State of New York. Anniversary Address before its Seventy-fifth Annual Meeting. By the President. Syracuse, N. Y., 1881. Presented by the N. Y. State Library.

Mercantile Library Association. New York. Sixty-fourth Annual Report of the Board of Direction. May, 1884–April, 1885. Presented by the Association.

Merchant Vessels of the United States. Ninth, Thirteenth, Fourteenth and Sixteenth Annual Lists of Bureau of Statistics. Washington, 1877–1884. Presented by the Hon. Secretary of the Treasury.

Meriden Water Department. Annual Reports for 1883 and 1884. Meriden. Presented by the Department.

Meteorological Council of Royal Society. Monthly Weather Report of the Meteorological Office for 1884 and 1885. Weekly Reports, January 1 to March 2, 1885. London, 1885. Presented by the Council.

Meteorological Council of Royal Society. Hourly Readings. 1882. Part 4, October–December. London, 1885. Observations at Stations of Second Order for 1880. London, 1885. Quarterly Weather Report. N. S. Part 2. April–June, 1877. London, 1885. Presented by the Council.

Meteorological Council of Royal Society. Report of, for Year ending March, 1884. London, 1885. Presented by the Council of the Society.

Meteorological Department. Government of India. Observations Made at Different Stations for September and October, 1884.
Presented by the Department.

Meteorological Department. Government of India. Report on Administration in 1883–84.

Meteorological Memoirs. India. Part 2, Vol. 3. Calcutta, 1884.
Presented by the Department.

Meteorological Observations for the Year 1884. Made at Rousdan Observatory, Devon. London, 1885. Presented by C. E. Peck.

Meteorological Observations. Results made at Toronto, Canada. 1854 to 1859 and 1860 to 1862. Presented by the Observatory.

Meteorological Observatory Department of Public Parks. Central Park, New York. Reports for 1884. Presented by the Director.

Meteorological Service Dominion of Canada. Instructions to Observers. C. T. Kingston, Superintendent. Toronto, 1878.
Presented by the Observatory.

Meteors. November, 1868. A Paper.
Presented by the U. S. Naval Observatory.

Michigan, Annual Reports of Secretary of State Board of Agriculture for 1872–83. Lansing. Presented by the State Board.

Michigan, Annual Reports relating to Births, Marriages and Deaths by the Secretary of State for 1868–70 and 1877–82. Lansing. Completing Set.
Presented by the Hon. Secretary of State.

Mine Hill and Schuylkill Haven Railroad Company. Annual Reports made in 1839–47, 1849, 1855–59, 1861, 1862, 1864.
Also Act of Incorporation. Philadelphia, 1854; and, Remarks upon a Memorial. Philadelphia, 1853.

Ministère de l'Instruction Publique. Bulletins des Bibliothèques et des Archives. Nos. 1 and 2. 1884. Paris. Presented by the Ministre.

Ministerio de Fomento de la Republica Mexicana. Boletin del. Nos. 8–36. 1885. Presented by the Ministre.

Minnesota, Geological and Natural History Survey of. Eleventh Annual Report for 1882. Completing Set.
Presented by N. H. Winchell, State Geologist.

Murray, Henry. The Art of Portrait Painting in Oil Colors. Seventh Edition. London, 1856.

National Microscopical Congress and American Society of Microscopists. Proceedings of Meetings. 1878 and 1879.
Presented by the American Society of Microscopists, which see.

National Observatory. Zones of Stars Observed. Vol. 1, Part 1. Washington, 1860. Presented by the Librarian of the U. S. Naval Observatory.

National Wholesale Drug Association. Proceedings. St. Louis, October 22 and 23, 1884.
Presented by A. B. Merriam, Secretary of the Association.

Nature La. Paris, 1878–84.

Nature. Vols. 29 and 30. London, 1884.

Naval Astronomical Expedition to Southern Hemisphere. Vols. 2, 3 and 6. J. M. Gilliss, Superintendent. Washington, 1855–56.

Naval Observatory, U. S. Branch. Communication from John Rogers to the Secretary of the Navy. Washington, 1878.

Naval Observatory, U. S. Reports on the Removal. Washington, 1877. Presented by the Observatory.

Navy of the United States. Register of Commissioned, Warrant and Volunteer Officers. January 1, 1865. Washington.

Navy of the United States. Register of Officers for 1884–85. Washington. Presented by Prof. J. R. Soley, Librarian Navy Department, U. S.

Newark Aqueduct Board. Annual Reports for 1877, 1883–84. Newark, 1878 and 1884–85. Presented by the Board.

New Bedford Board of Health. First to Sixth Annual Reports, 1879–84. Presented by the Board.

New Britain, Conn. Annual Reports of the Mayor and other Departments for Year ending April, 1885. Presented by the Mayor.

New Brunswick, N. J. Twelfth Annual Report of the Water Commissioners. 1884. Presented by the Commissioners.

Newcomb, S. Investigation of Corrections to Hansen's Tables of the Moon. Washington, 1876. Presented by U. S. Naval Observatory.

New Haven, Conn. Twelfth Annual Report, and Rules and Regulations of the Board of Health, 1885. Presented by the Board.

New Jersey. Eleventh Annual Report of State Board of Agriculture, 1883–84. Newton, 1884. Presented by A. H. Gangewer.

New Jersey State Board of Health. Annual Report for 1881. Mt. Holly. Presented by A. H. Gangewer.

New Jersey State Board of Health. Annual Report for 1884. Trenton, N. J. Presented by the Board.

New Jersey. Seventh Annual Report of Bureau of Statistics of Labor and Industry. 1884. Presented by the Bureau.

New Jersey Historical Society. Collections Vols. 1, 2, 4, to 7, including Supplement to Vol. 6.
Proceedings. First Series. Vols. 1, 3, 4, 7 to 10. Second Series. Vols. 1–8, 1867–1884, 1845–1866, 1869–1884.
Presented by the Society.

New Jersey Sanitary Commission. Report to the Governor for 1866. Trenton, 1867. Presented by A. H. Gangewer.

New Jersey State Agricultural Experiment Station. Second, Third and Fifth Annual Reports of, for 1881, 1882 and 1884. Bulletins A, and 11–22; 24–26 and 29 to 33. Presented by the Station.

Newport, R. I. Eighteenth and Nineteenth Annual Reports of the School Committee with the Report of the Head-Master of Rogers High School. 1882–84. Presented by the Superintendent.

Newton, Mass. Auditor's Annual Report of the Finances of the City for 1882. Presented by the Auditor.

THE "NOVELTIES" EXHIBITION OF THE FRANKLIN INSTITUTE—1886.

THE "NOVELTIES" EXHIBITION—the twenty-ninth Exhibition held under the direction of the FRANKLIN INSTITUTE, of the State of Pennsylvania, for the Promotion of the Mechanic Arts—was opened on Tuesday, September 15, 1885, and closed Saturday, October 31, 1885.

The following classification was decided upon, viz.:

(1.) Agricultural Machines, Implements and Products.

(2.) Arms, Ordnance, Projectiles, Military Goods and Equipments.

(3.) Caoutchouc and other Plastics, including Vulcanized and Celluloid Manufactures.

(4 *a*.) China, Porcelain.

(4 *b*.) Glass.

(4 *c*.) Lapidary's-work and Glass-cutting.

(5 *a*.) Coal, Minerals and Metallurgy.

(5 *b*.) Metallurgical Processes and Products.

(6.) Distillation, Brewing, Refrigeration and Fermentation-Appliances and Products.

(7.) Drugs, Chemicals, Dye-stuffs, Paints, Soap and Perfumery, and Appliances therefor, and Pharmaceutical Apparatus.

(8.) Electric Lighting, Motors, Dynamos, Generators and Batteries.

(9.) Educational Appliances.

(10 *a*.) Furniture.

(10 *b*.) Carpets and Upholstery.

(10 *c*.) Interior House Decoration.

(10 *d*.) Hats and Wearing Apparel, Umbrellas, etc.

(11 *a*.) Transmission of Power.

(11 *b*.) Steam Engines.

(11 *c*.) Gas Engines and Caloric Engines.

(11 *d*.) Steam Pumps and Injectors.

(11 *e*.) Hydraulic and Pneumatic Machinery.

(11 *f*.) Boilers and Furnaces.

(11 *g*.) Steam Heating and Ventilation.

(12 *a*.) Gas Manufacture for Illumination and Heating, and Apparatus therefor, including Coal and Oil Gas, and Natural Gas Appliances.

(12 *b*.) Gas Utilizing Apparatus, including Heating and Cooking Stoves, Burners for Illumination, etc., Natural Gas Burners and Furnaces.

(12 *c*.) Lamps and other Illuminating Appliances not enumerated above.

(13 *a*.) Machinists' Metal-working Tools and Machine Shop, Foundry and Forge Appliances.

(13 *b*.) Railway and other Transportation Appliances; Elevators, Freight Wagons, Trucks, etc.; Road-making, etc.; Navigation.

(13 *c*.) Coach Work, Farriery.

(13 *d*.) Wood-working and Stone-working Machines.

(14 *a*.) Photography.

(14 *b*.) Fine Arts.

(14 *c*.) Printing, Lithography and Paper Machines and Appliances.

(14 *d*.) Stationery and Paper.

(14 *e*.) Books and Book Binding, Case Making, etc.

(14 *f*.) Fancy Goods, Stationers' Sundries, Sporting Goods and Supplies, Toys, etc.

(14 *g*.) Show Cases and Store Furniture and Service.

(15 *a*.) Textiles and Spun Goods.

(15 *b*.) Carding and Spinning.

(15 *c*.) Weaving.

(15 *d*.) Knitting.

(15 *e*.) Sewing Machines and Sewing Machine Appliances.

(16 *a*.) Surgical and Dental Instruments and Appliances.

(16 *b*.) Philosophical and Optical Instruments.

(16 *c*.) Apparatus and Instruments of Precision.

(17 *a*) Life Saving and Fire Extinguishing and Preventing Appliances.

(17 *b*.) Building Material, Brick, Tile, Terra Cotta, etc.

(17 *c*.) Machines for Manufacturing Bricks, Tile, Terra Cotta, etc.

(17 *d*.) Building Hardware, including Tools for Joiners' use, etc.

(17 *e*.) Plumbing and Sanitary Appliances.

(17 *f.*) Housekeeping and Storekeeping Hardware.

(17 *g.*) Scales for Weighing.

(18.) Musical Instruments.

(19.) Machines for preparing Food Products, Confectionery, etc.

(20.) Ladies' Committee.

(21.) Stoves and Heaters, and Materials therefor.

ABSTRACTS OF REPORTS OF THE JUDGES.

GROUP I.—AGRICULTURAL MACHINES, IMPLEMENTS AND PRODUCTS.

Judges:—Israel H. Johnson, Jr., *Chm.;* H. B. Riehlé, Hugo Bilgram, John A. Wiedersheim.

W. L. NASSAU, NEWARK, DEL.:

Williams's Lawn Mowers.—Similar to other machines now in use, although containing some new features in design and construction. By means of two spring supports, one at either end of the cutter-head and containing a number of graded holes which catch on pins or lugs on the frame, the machine can instantly be adjusted to cut grass any desired height. The spiral knife or cutter is made in a special form with a great curve or shearing angle to the stationary cutter, therefore brings less cutting surface in contact at one point than is found in other machines. The cutter-bar is provided with small projections or guards, which prevent the grass from being pushed away instead of being cut, therefore insuring a more even surface to the lawn grass; the cutter-head is adjusted to the cutter bar by means of two adjusting screws. (*A Silver Medal.*)

Williams's Improved Drill Tube.—The foot of the tube is so shaped as to make a flat bottom trench about two inches wide, in which the wheat and phosphates are spread over the entire surface; this giving a better result from the same amount of wheat and phosphates distributed. A wheel is attached to the back part of the drill tube, which acts as a covering device; it is arranged with flanges that throw the soil back in the trench made by the foot of tube, at the same time compresses the soil over the wheat, leaving field in a good shape and further rolling unnecessary. (*A Silver Medal.*)

Approved by Board of Chairmen, November 5, 1885.

H. R. HEYL, *Chm.*

GROUP 2.—ARMS, ORDNANCE, PROJECTILES, MILITARY GOODS AND EQUIPMENTS.

No exhibits.

GROUP 3.—CAOUTCHOUC AND OTHER PLASTICS, INCLUDING VULCANIZED AND CELLULOID MANUFACTURES.

Judges:—Sam'l P. Sadtler, *Chm.;* Henry Morton, W. H. Burk, Wm. C. Head, Horace W. Sellers, Wm. H. Wahl.

CELLULOID MANUFACTURING COMPANY, NEWARK, N. J.:

Celluloid Products.—The Celluloid Manufacturing Company, of Newark, N. J., make a most elaborate and instructive exhibit of what has rapidly developed into a great chemical industry. They show the crude material as turned out from their factory in rods, tubing, sheet and rolls, and a very varied collection of beautiful and useful products manufactured therefrom. The Celluloid Manufacturing Company, of Newark, are the sole manufacturers of the material under the patents of the Hyatt Brothers, issued in 1870, and they give rights to some sixteen separate companies and firms for the manufacture of as many classes of articles from the material. The products of all these subsidiary companies are represented in this exhibit and are described in the illustrated pamphlet issued by the parent company.

The material now known as celluloid was first prepared by an English inventor, Alexander Parkes, about 1855, and introduced by him to the world under the name of "Parkesine." His method at first consisted in preparing nitro-cellulose, or pyroxyline, and then dissolving it in liquid solvents like wood naphtha, mineral naphtha, nitro-benzol, or glacial acetic acid, and then driving off the solvent by evaporation or precipitating the pyroxyline out from the solution as a semi-solid, curdy mass, which is then pressed and dried. Later, he adopted the use of an alcoholic solution of camphor for the solvent. Indeed, the English manufacturers stated that all of the ordinary volatile solvents are improved by the addition of camphor. Parkes abandoned the manufacture in 1867, on account of the difficulties in its manipulation, although he made a fine exhibit of his products at the Paris Exposition, in 1868, obtaining a prize medal therefor. An Englishman, named Daniel Spill, in 1869, revived the use of one of Parkes's methods,

and, indeed, got a patent for the use of camphor or camphor oil in connection with alcohol as a solvent for the pyroxyline, but his patent was afterwards declared valueless by Judge Blatchford, in a suit brought by Spill against the Celluloid Company.

After the failure of Parkes, the first inventor, in making a merchantable article, no new discovery was made in the matter until the Hyatt brothers, then of Albany, N. Y., after considerable experimenting, found that solid camphor, when in the melted state, became a perfect solvent for the pyroxyline, so that by thoroughly mixing the comminuted pyroxyline with camphor and heating, the mass became perfectly homogeneous and plastic. This discovery was patented July 12, 1870, and reissued in an improved form June 23, 1874, and forms the basis of the present manufacture of the Celluloid Company, of Newark. The only other manufacturers of similar products in this country are the American Zylonite Company, of Adams, Mass., who are now the defendants in a suit brought by the Celluloid Manufacturing Company, for infringement of their patents.

It is stated that at the present time there is only one manufactory of celluloid in France, at Staines, on the Seine, and that running under license of the Celluloid Manufacturing Company; that works started in Germany by a Hanover firm, were abandoned because of the explosive character of the material, and that a company recently engaged in its manufacture in England has closed out. The American manufacturers then seem to control almost the entire field. They show evidence, however, by this magnificent display here at the "Novelties" Exhibition, that they are pushing its introduction as a valuable substitute for ivory, amber, rubber and leather with great energy and success.

If we compare the specimens of celluloid materials finished in imitation of ivory with those shown some years ago, when it was first brought to public notice, we can see what decided improvements have been made in its manufacture. The same is true of the excellent imitations of amber, coral and tortoise-shell. The applications in coating linen as a substitute for patent leather, in coating metal in harness trappings as a substitute for both leather and rubber, in the manufacture of celluloid veneers and moulding for picture frames, cornices, panels, etc., in the manufacture of celluloid plates for artificial teeth as a substitute for vulcanite, in

the manufacture of the light but hard celluloid stereotype plates as a substitute for the heavy and easily damaged ones of stereotype metal, and innumerable minor articles here exhibited, all show a marked value, in their serviceableness and adaptability to the uses proposed. Nor must it be overlooked that we have evidence in this exhibit that celluloid is not merely excellently adapted for use as a substitute for other more expensive materials, but has in itself valuable properties possessed by none of the other substances. Thus, on account of its perfect uniformity of color and density, it is better adapted for the manufacture of piano keys and billiard balls than ivory would be. Similarly in the manufacture of trusses it is not merely a substitute for rubber, but possesses decided advantages on account of its strength, perfect elasticity, and freedom from constituents injurious to health.

Some of the applications shown in this exhibit are quite recent, but promise to be of equal importance with those more generally known.

For the completeness and variety of the collection of celluloid products and articles manufactured therefrom, and the evidence of great improvement in the manufacture of a valuable article, and the establishment of new and important applications therefor—

(*A Silver Medal.*)

ISAAC WENDELL, PHILADELPHIA:

Asbestos Praducts.—This exhibit is intended to illustrate what is claimed to be a new article of manufacture, consisting of a mixture of asbestos and various substances, the latter differing according to the several purposes to which the compound may be applied.

The exhibitor claims that it is adapted for journal bearings, for cars, shafting and machinery, spindle steps, steam-pipe covering, crucibles, acid vats, fire-proofing, insulators for all electrical purposes, etc. It is to the compound as prepared for journal bearings that especial claim is made for its usefulness, and for this purpose the mixture consists chiefly of asbestos, powdered and in fibre, plumbago, and silicate of soda.

Without an opportunity to test the properties of these asbestos compounds, it is impossible to determine their advantages.

(*No award.*).

GROUP 4*a*.—CHINA AND PORCELAIN.

Judges:—Wm. A. Porter, *Chm.;* L. W. Miller, John Sartain, Addison B. Burk, Wm. H. Miller.

The judges appointed to examine the articles exhibited in Group 4*a* (china and porcelain) respectfully report that they have made a careful examination of the three exhibits in this group, and are pleased to observe the great advance that has been recently made in the production of useful and decorated ware in china, porcelain and earthenware.

OTT & BREWER, TRENTON, N. J.

Messrs. Ott & Brewer, of Trenton, N. J., exhibited decorated Belleek china in *tête-à-tête* sets, vases and novelties in porcelain; decorated opaque china, in dinner and toilet ware, and decorated white granite in dinner and toilet ware. The Belleek china is a reproduction of the fine porcelain of Belleek, Ireland, and is of such rare beauty that it deserves a title of its own. We do not hesitate to say that the ware is of a superior body to that from which it is named and in strength, delicacy, lightness and marvellous transparency it is all that could be desired. The artistic decoration is also in keeping with the high quality of the ware itself. Many of the vases and art objects exhibited were decorated in raised gold and bronzes of various shades after the manner of the famous Worcester ware. Included in this branch of the exhibit, was a fine bust of Cleopatra, used as a central ornament in the group of objects. Two plaques, decorated in *pâte-sur-pâte*, were also fine examples of artistic work. The great variety of this exhibit precludes a more particular description, but the judges could not fail to be impressed by these evidences of the great strides made in the ceramic manufacture within the last few years. It is only recently that the higher grades of china and porcelain manufacture and decoration have been attempted, and already the exhibit made by Ott & Brewer is fit to be placed by the side of the best work of the European potteries whose products have been imitated.

The decorated opaque china in dinner and toilet ware represents the useful as distinguished from the distinctively ornamental part of the exhibit. The ware is of excellent form and quality, and much of the decoration is highly artistic. The workmanship is all that could be desired. The same may be said of the decorated

white granite in dinner and toilet ware, some of the latter being made very attractive by the delicacy of the ground laying. In view of the high degree of success attained by Ott & Brewer in this most difficult branch of manufacture, we would gladly have them given the highest award at the disposal of the INSTITUTE; but under the limitations set upon the judges, we can only recommend that they be given a silver medal for their very creditable display. If it should be possible to do so, we would also recommend that their claims be referred to the Committee on Science and the Arts for such other award as may be proper for their adaptation of American clays to the production of the finest porcelain.

(*A Silver Medal and recommendation to the Committee on Science and the Arts.*)

J. JEFFRIES & CO., PHILADELPHIA.

J. Jeffries & Co., of Philadelphia, exhibited pitchers, tea-pots, and other articles of domestic use made of earthenware and decorated by colored glazes, or hand-painted on the body, or painted in slip. The ware was of good form and quality, and the decoration simple, inexpensive, and adapted to the character of the ware. The exhibit was creditable. (*A Bronze Medal.*)

GALLOWAY, GRAFF & CO., PHILADELPHIA.

Galloway, Graff & Co., Philadelphia, exhibited vases for interior decoration in the faïence styles. The ware was in general of good form, the background colors, boldly laid on, harmonious in tones of color and the glaze appeared to be of fine quality and suitable to the body.

The plain pieces and those decorated in underglaze are worthy of high commendation. The suggested use of oil colors in decorating these vases, of which samples were also shown for the guidance of purchasers, is not to be commended, since it leads to the use of high colors not compatible with the firing required for underglaze nor in harmony to the educated eye, with the tones which give the highest value to underglaze work.

For the display of undecorated vases and those decorated in underglaze— (*A Bronze Medal.*)

Approved by Board of Chairmen, November 5, 1885.

H. R. HEYL, *Chm.*

4*b*, 4*c*. GLASS, LAPIDARY'S WORK AND GLASS CUTTING.

Judges:—L. W. Miller, *Chm.*; Wm. A. Porter, T. C. Search, Isaac Norris, M. D., Fred. Graff, Addison B. Burk, Samuel Sartain.

The committee appointed to examine groups 4*b* and 4*c*, respectfully submit the following report, that they have carefully examined every exhibit which was assigned to their groups in the classification adopted, which exhibits were as follows:

4b. Glass.

(1.) *Ludwig Moser*, Philadelphia, and Carlsbad, Germany, consisting of glassware from Bohemia, colored, engraved, and otherwise decorated.

(2.) *Tyndale & Mitchell Company*, Philadelphia, china, glassware, and fine pottery.

(3.) *Frank Walcot*, Lyons, France, slagware, imitations of marble or granite ornaments, flower pots, vases, fruit dishes, etc., made from iron and copper slag.

(4.) *T. E. Miles*, London, England, slagware, ornaments, vases, dishes, etc., manufactured from iron, copper and lava slag.

4c. Lapidary's Work and Glass Cutting.

(5.) *James M. Beath*, Philadelphia, lapidary's work, showing the cut of cutting and polishing precious stones.

(6.) *F. E. Mitchell*, Philadelphia, improved high speed grinding machines for opticians' work and other forms of glass cutting.

REGARDING THE FIRST named exhibit, your judges have found it highly interesting, and they desire to express by means of the highest award at their disposal, their appreciation of its conspicuous merit. It consists of beautiful objects, such as vases, pitchers, tankards, goblets, small boxes, etc., sometimes original in design, but for the most part reproductions of rare and precious old Venetain or German work.

To the beautifully colored bodies for whose excellence the Bohemians have long been famous, has been added an exquisite form of decoration in gold and enamel, beautifully executed, the method of applying which is claimed by the exhibitor as his own invention recently patented in Austria and in Germany,

(*A Silver Medal.*)